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THE ELECTRICAL WORLD

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The Weston Mammoth Incandescence Lamp.

Scattered through the various sections of the International Electrical Exhibition building are large incandescence lamps in the centre of reflectors, which diffuse their rays over the objects beneath. One of the lamps and reflectors is illustrated by Fig. 1.

These lamps are a novelty in exhibitions and attract much attention, both on account of their great size and their evident utility. Two of them are over THE ELECTRICAL WORLD press, and give much satisfaction. They are adapted to street lighting and, indeed, we believe, were originally intended for that purpose. Fig. 2 shows one of them mounted with its reflector on a graceful lamp-post for the street.

Fig 3 shows one of the lamps mounted in its socket, from which it may be removed to be replaced at will, but be thoroughly fastened in place by the bayonet-joint.

We gather the following facts from the United States Electric Lighting Co., who manufacture these lamps. The carbon filament is made by carbonizing "tamadine," Mr. Weston's preparation from cellulose, and is made to have a resistance of from 68 to 70 ohms while hot. The lamps are run in "multiple series," that is to say, there are five parallel series, containing four lamps each. The source of the electricity supplied to each 20 lamps is a 20-arc lamp dynamo of Mr. Weston's pattern, having an electromotive force sufficient to sustain a difference of potential of 160 volts between the binding-posts of each lamp. These data, mathematically arranged, give the following equations:

$$\frac{160 \text{ volts}}{70 \text{ ohms}} = 2.3 \text{ ampères strength of current, and}$$

2.3 ampères × 160 volts = 368 watts = 0.49 horse-power energy of each light. It is said that the actual commercial efficiency of these lamps is 125 candle-power to each lamp, or 250 candle-power to each horse-power.

It is necessary, under this multiple series system, to supply each series with the resistance boxes shown in Fig. 4. Each lamp has its box having a resistance approximately that of the lamp with which it is associated. Above each box there is shown on the wall a switch, or cut-out, by which the lamp belonging to it may be extinguished by simply turning the handle shown at its centre. The switch is shown by Fig. 5 in enlarged view and by Fig. 6 in its interior detail.

When the current is turned from the lamp, on the wires running from the top of the apparatus, by movement of the handle the T-shaped lever in the switch flies from the two L-shaped spring-contacts on one side to a like two on the other side. The first two are terminals of the branch to the lamp, and the latter two are like terminals of the branch circuit to the resistance box. In this manner the resistance in the box is substituted for the lamp, or *vice versa*.

One of the resistance boxes is shown with its cover removed to exhibit the open way the resistance coils are placed in the box, which has its cover perforated to admit free access of air for cooling purposes.

In case any lamp fails, the electro-magnetic apparatus in its associate box immediately operates to make contacts which insure the closing the circuit through the resistance coils.

The small electromagnet at the right of the board and with its cover dropped to the horizontal, performs the function of completely breaking the circuit through the series of resistance boxes as soon as all the lamps are extinguished, so as to stop the waste of power which would otherwise exist.

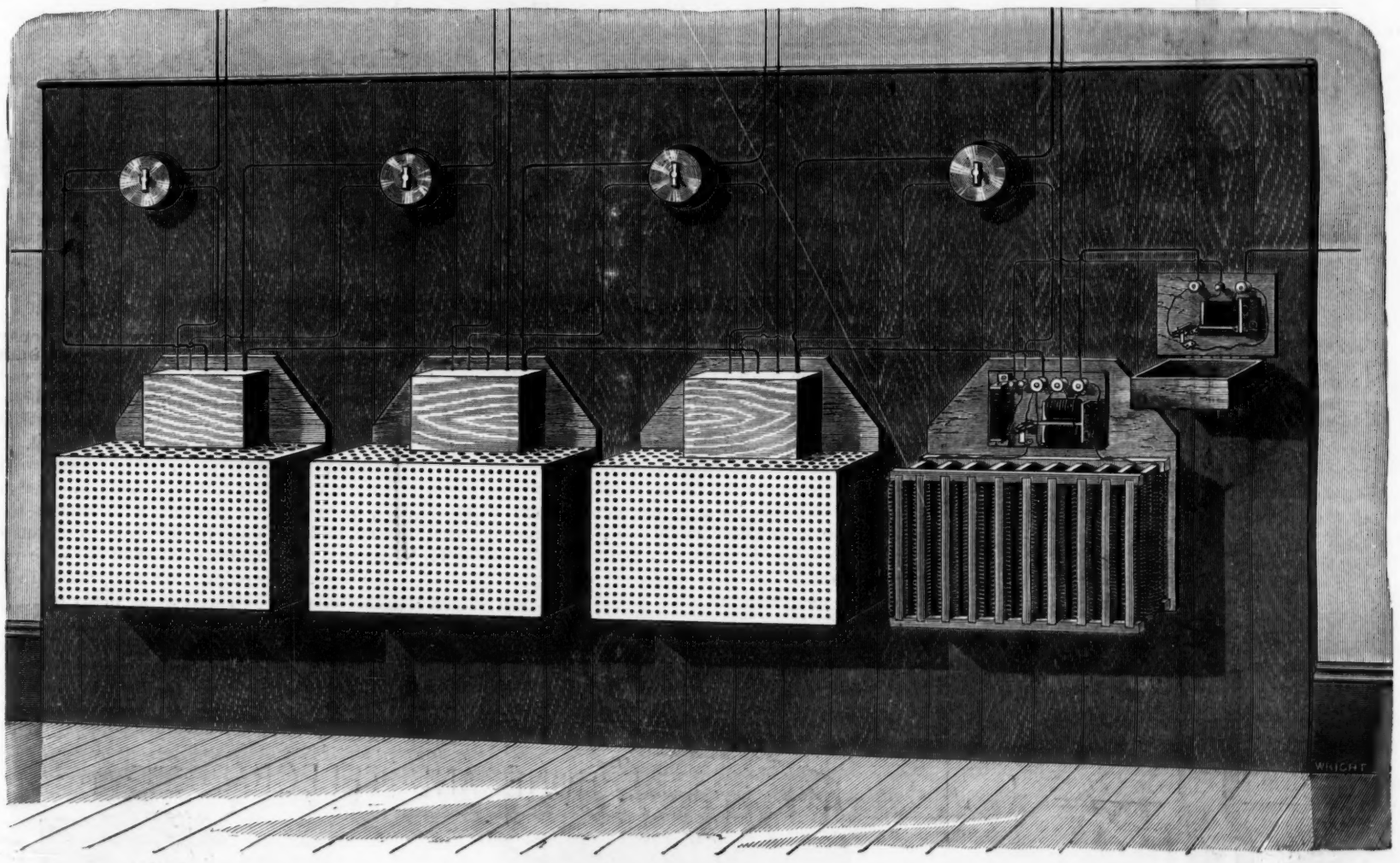

FIG. 4.—RESISTANCE BOXES FOR WESTON INCANDESCENCE LAMPS, MULTIPLE SERIES SYSTEM.

American Institute of Electrical Engineers.

The Philadelphia meeting on Tuesday, the 7th of October, was held in Parlor C of the Continental Hotel. On Wednesday two meetings were held at the rooms of the Institute in the Electrical Exhibition Building; and a like number of meetings were held on Thursday, October 9th, at the same place. About twelve papers on a variety of electrical subjects were read and vigorously discussed. Our reporter was present and we will give to our readers some or all of the papers and discussions thereon in our present and future issues, as we can find room for them. Prof. Brackett's paper on his Experimental Method with Dynamos is printed in this number. It is a matter of much interest to the manufacturer of dynamos, and to the experimentalist.

Electric Ballooning.

The following particulars have been published in France with regard to the tests of MM. Renard and Krebs, with a steerable balloon, an elongated oval in shape, and placed horizontally instead of perpendicular to the car:

The balloon constructed by these gentlemen is 50.42 meters in length and 8.4 in diameter, and has a capacity of 1,864 cubic meters.

The electric motor is constructed in such a way as to make it possible to develop upon the shaft 8.5 horse-power, representing for the current at the entrance terminals 12 horse-power. It transmits its motion to the shaft of the screw through the intermedium of a pinion that gears with a large wheel.

The pile is divided into four sections that are capable of being grouped for volume or tension in three different ways. Its weight is 19.35 kilogrammes.

On August 9, 1884, at 4 o'clock in the afternoon, the air being nearly quiet, the balloon, being freed and possessing a very slight ascensional power, rose slowly in the air. The machine was set in motion, and under its impulsion the balloon soon quickened its pace, faithfully obeying the least indications of its rudder.

The first direction taken was from north to south, over the plateau from Choisy to Versailles. So as not to stand over the trees, however, the direction was changed and the fore end of the balloon pointed towards Versailles. Over Villacoublay, about 4 kilometers from Chalais, the aeronauts, entirely satisfied with the behavior of the balloon thus far, decided to retrace their steps, and attempt to descend at Chalais, notwithstanding the slight space that existed free from trees. The balloon made its half turn to the right by a very slight angle (about 11°) given to the rudder. The diameter of the circle described was about 300 meters. The dome of the Invalides, taken as a

directing point, then left Chalais a little to the left of the route. Reaching the level of this point, the balloon changed its direction to the left with as much ease as it did before, and was soon hovering at a height of 300 meters over its starting point.

Its tendency to descend at this moment was shown the more by a manœuvre of the valve. During this time it became necessary to run backward and forward several times, in order to bring the balloon over the spot chosen for anchorage. At a distance of 80 meters above the ground the rope was thrown out, and, being seized by men, the balloon was drawn to the very field from whence it had started.

In a view given the balloon is shown in profile, at the moment when it is beginning to be set in motion. The

Fig. 2.—Street Post for Weston Incandescence Lamp.

screw is in front, and. in revolving, it drives the air laterally over the two sides of the large, elongated car, 33 meters in length. We are informed that the dynamo employed was constructed by M. Gramme. The generator of electricity consisted of a battery of piles whose nature has not been made known by Captain Renard. The travelers stand in the centre of the car, and one of them runs the machine, while the other governs the rudder.

Mr. Preece in St. Louis.—Our advices of Oct. 1, from St. Louis, are that Mr. W. H. Preece arrived in that city on the 30th ult. from Chicago, with Col. R. C. Clowry, of the Western Union. Mr. Preece, who was escorted about the city by Col. L. H. Baker, superintendent of the St. Louis Division of the Western Union, is looking into recent developments here in telegraphy, but is particularly studying the telephone system of the country with a view to the introduction of its best points into England. Mr. Preece admits that the English public "has been very poorly served" telephonically, but he is the man to improve the service materially.

An Experimental Method of Studying the Dynamo Machine.*

BY PROF. C. F. BRACKETT, PRINCETON, N. J.

I propose to give a short account of a method of experimentally investigating the dynamo machine, which has been devised and put in practice in the Physical Laboratory of the College of New Jersey. Its principal feature consists in the use of an exploring coil, by means of which it is easy to determine the relative value of any point of the magnetic field in which the armature revolves.

(1) When the field magnets are excited by their normal current, generated by another machine, the armature of the machine under investigation being removed. (2). When the field is modified by the presence of the iron core of the armature revolving without the usually accompanying coils. (3). When the field is modified by the action of the coils of the armature revolving without their iron core, but carrying the current which usually traverses them. (4). When the normally constructed armature is in operation in the production of the current in the ordinary way.

In order to estimate the energy consumed in any given case, the machine has its field-magnets balanced on knife edges, as I have elsewhere pointed out. The couple required to hold the magnets in opposition to the couple tending to make them revolve and the measured velocity of revolution enables us to determine the power expended in any given case.

The special arrangements are as follows:

(1.) The armature is removed from the arbor and in its place is secured a wooden hub, to which is attached the exploring coil, the latter having the same form as one of the coils of the armature though it may consist of one or of many turns of fine insulated wire, the number being determined by the conditions involved in the case under consideration. One end of the wire of the exploring-coil enters a hole in its side and passes along the axis of the arbor, which is bored out for that purpose, and comes out centrally at its end, where it is soldered to a short cylindrical wire of steel which is fixed by an insulating plug to the extremity of the arbor and concentrically with it. This steel wire passes through the side of an iron cup below the surface of mercury which it contains. The cup is supported by an insulating stand. The other end of the wire of the coil is soldered to the single narrow bar of a commutator cylinder which is fixed to the arbor and so arranged that it can be set always coaxially, but so that a radius passing through the bar shall make any required angle with a radius passing through the exploring coil already described.

A divided circle fixed to the field-magnets enables this to be done conveniently. A spring or "brush," insulated from the metal of the machine, is so adjusted that it shall touch the bar at the instant it is passing under it. If a wire join this spring to the mercury in the iron cup there will be a closed metallic circuit at the moment when the brush is in contact with the commutator bar; and since the coil is moving through the magnetic field, due to the field magnets, there will be at that instant an electromotive force, and so a current set up in the coil. This is evidently repeated at every revolution, and, if these be rapid enough, the result will approach in character a continuous current.

If we introduce into the circuit a condenser it will be fully charged at the potential due to the intensity of the field at the point passed by the exploring coil at the instant when the commutator coil is in contact with the brush. The condenser may be discharged through a ballistic galvanometer and the deflection noted. If, now, the commutator be so set as to be in contact with the brush when the exploring coil is passing another point in the field, whose angular position with respect to the first is known, and the observation made by means of the condenser and galvanometer, we shall have the relative value of the field at this point. We can proceed in like manner to determine the potential at as many points in the field as we desire. We thus have the necessary data for plotting a curve that shall show the distribution of the free magnetism of the field in which the armature of the machine turns when it is present. Instead of the condenser and the ballistic galvanometer, the quadrant electrometer may be employed more conveniently. It is in this case necessary to see that the electrometer is not affected by charges which have their origin in the friction of the belt which drives the machine. Proper care being taken to avoid such accidental disturbances, we may eventually plot our curve from the direct readings of the electrometer.

(2). An exploring-coil is now placed on an iron ring, in all respects similar to that employed in the construction of the normal armature. And the ends are joined in exactly the same way as before. The coil is driven with uniform speed as before and the several observations are taken in the same way, and the result is plotted. The resulting curve shows how the magnetic field due to the field magnets is modified by the presence of the revolving iron ring.

(3.) An armature in all respects similar to the normal armature of the machine, except that it is wound on a wooden core, is now placed on the arbor. An exploring-coil is wound upon it properly as before. The commuta-

*Read at the Philadelphia meeting of the American Institute of Electrical Engineers, October, 1884.

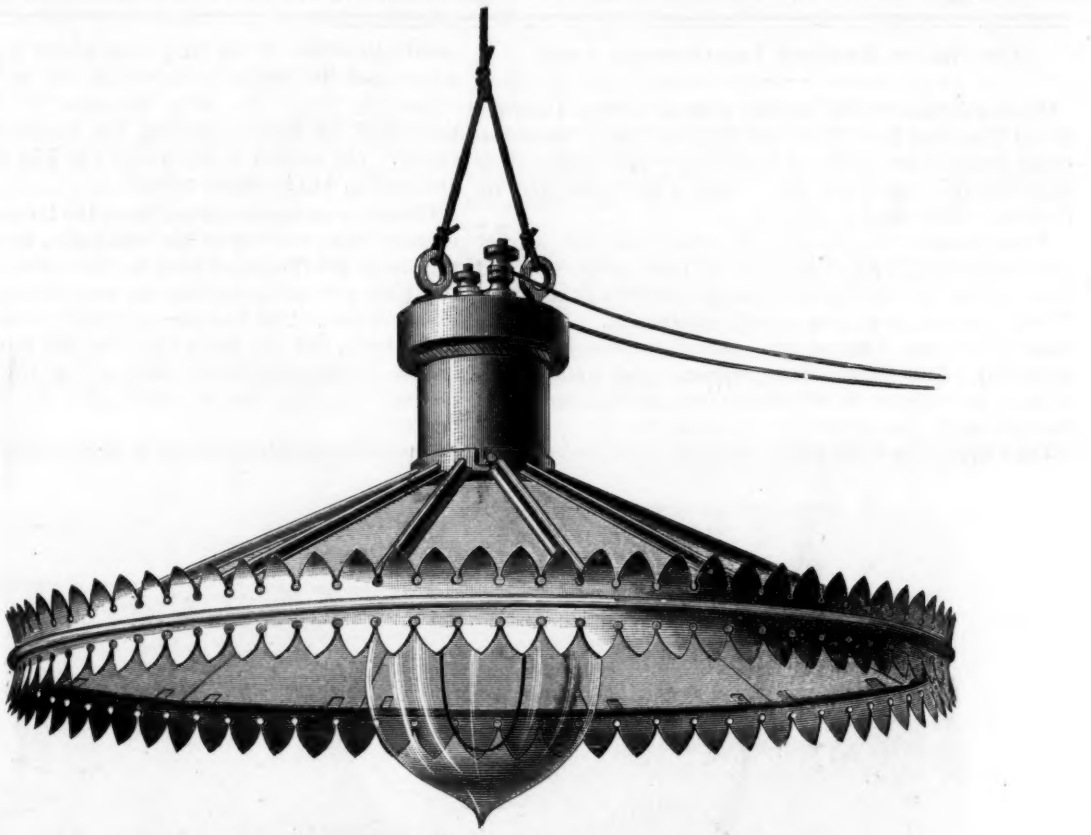

Fig. 1.—Weston Mammoth Incandescence Lamp, with Reflector

Fig. 5.—Cut-Out for Weston Incandescence Lamp.

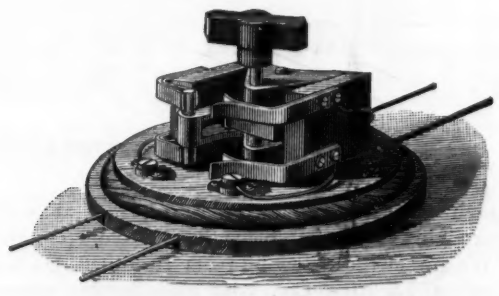

Fig. 6.—Interior Details of Cut-Out.

tor brushes of the machine are put in place and adjusted so that the current from the feeding machine shall traverse not only the magnets but also the armature. Now, on causing the machine to revolve with uniform velocity, as before, we can find the necessary data for plotting the curve representing the magnetic field as modified by the presence of the revolving coils together with the currents which traverse them.

(4.) The proper armature of the machine is now put in place and an exploring coil is wound upon it as in the last case.

The proper connections are made and the readings of the electrometer, as affected by the coil in the different positions which it is successively made to assume are taken. The curve plotted from them shows the character of the field as modified by the action of the armature. It is obvious that we may now use the method of exploration here pointed out to determine what are the modifications due to different speeds of revolution. Also we may employ it to determine the proper form of the "cheek pieces" of the field magnets, the proper amount of iron to give the best results, and a great variety of other matters that will readily occur to one. The exact method of joining the ends of the exploring-coil to the electrometer which is here pointed out need not be followed in every case, as alternative methods will suggest themselves.

A Delicate Operation.

We take the subjoined from the Buffalo *Express* of recent date:

"In July last Michael Sullivan, a machinist at work for Farrar & Trefts, was struck in the left eye by a piece of steel. His eye had to be entirely taken out. Last Thursday, while using a steel tool called a "set," a piece broke off and was imbedded in the vitreous humor of the right eye, making a dangerous and exceedingly painful wound. He was operated upon unsuccessfully the next day, and on Saturday was brought to Dr. A. A. Hubbell, oculist. A special magnet was made, the patient chloroformed. and by a very delicate operation the steel was removed. The patient was doing well last evening, and unless inflammation sets in he will probably recover the use of the eye. The operation, while it reflects credit on Dr. Hubbell, also speaks forcibly in favor of Mr. Charles Plumb, the electrician, of Niagara street. The piece of steel removed was one-eighth by three-sixteenths of an inch in size and as thick as a calling card. Its edges were jagged and it was embedded in the vitreous humor of the eye, which is about the consistency of varnish. It was necessary, if the operation be successful, that the magnet used be a powerful one, and that its power be concentrated in a very small point. Mr. Plumb set to work, and succeeded in producing an electro-magnet designed on principles laid down by Prof. Henry. With this magnet the operation was successfully performed, which had once before been unsuccessfully attempted with what is supposed to be the most powerful magnet of the kind made."

Mr. Charles Plumb writes us that while the most powerful magnet he can find on record is with a polar extension of $\frac{3}{32}$ in. diameter, and is $\frac{1}{2}$ in. long, capable of lifting with one bichromate cell 300 grains, the magnet used on this occasion was of $\frac{1}{32}$ diameter and 1 inch long, and lifted with the one bichromate cell 2,084 grains. He states that the man was rapidly recovering.

THE COMMERCIAL CABLE IN BROOKLYN, N. Y.—Commissioner Fleeman, Brooklyn, has granted a permit to the Commercial Cable Company to open the streets through which the company is to lay the cable lines. It is to run down Flatbush avenue from the city line to Vanderbilt, through Vanderbilt to Park, down Park to Hudson avenue, through Hudson avenue to Water street, and through Water street to the Bridge, where it will cross to New York. The company has paid the city $1,000 for the right to lay the cable and has given indemnity bonds in the sum of $10,000. The cable has been landed at Sheepshead Bay.

POSTAL DIRECTORATE.—The Directors of the Postal Telegraph Company have accepted the resignation of Mr. H. Cummins as a Director and General Manager of that company. The vacancy in the Board of Directors was filled by the election of Frank M. Gillett, of Gillet & Mills, bankers, and Henry Rosener was elected second Vice-President and General Manager. George S. Coe, the banker, who is the First Vice-President of the company, made a statement setting forth its favorable business prospects.

LECTURING ON MAGNETISM.—Mr. William Finn, superintendent of the Wheatstone Department at the Western Union Telegraph office, Buffalo, N. Y., delivered a lecture before the Electrical Society, Oct. 3, upon "Magnetism." It was the first, or introductory lecture of a course upon the subject, and was exceedingly interesting not only to the electricians present, but to the ladies in the audience. Mr. Finn illustrated his discourse by a series of interesting experiments. The first was by the breaking of a magnet to show that the parts were also magnets and had their positive and negative poles. The next point exemplified was that an obstruction coming between the magnet and the metallic object does not destroy the attraction. The third and last point noticed was that of polarization. He magnetized iron filings and showed by the attraction of the horseshoe how the points turned toward it. The next lecture will be delivered October 17.

Annual Meeting of the Western Union Company.

The annual meeting of the shareholders of the Western Union Telegraph Company was held on Oct. 9. Ex-Governor Cornell presided. The number of shares of stock represented was 630,285. The following-named gentlemen were elected directors without contest: Norvin Green, Thomas T. Eckert, Alonzo B. Cornell, Jay Gould, Russell Sage, John T. Terry, John Van Horne, George D. Morgan, Harrison Durkee, Sidney Dillon, Cyrus W. Field, George J. Gould, Abraham R. Van Nest, John Pender, M. P., Henry Weaver, Percy R. Pyne, Robert Lenox Kennedy, Hugh J. Jewett, J. Pierpont Morgan, Frederick L. Ames, John Hay, William D. Bishop, C. P. Huntington, George B. Roberts, Frank Work, Samuel Sloan, Erastus Wiman, John J. Astor, Chauncey M. Depew, James W. Clendenin.

President Norvin Green submitted his annual report. It stated that the bonded indebtedness of the company

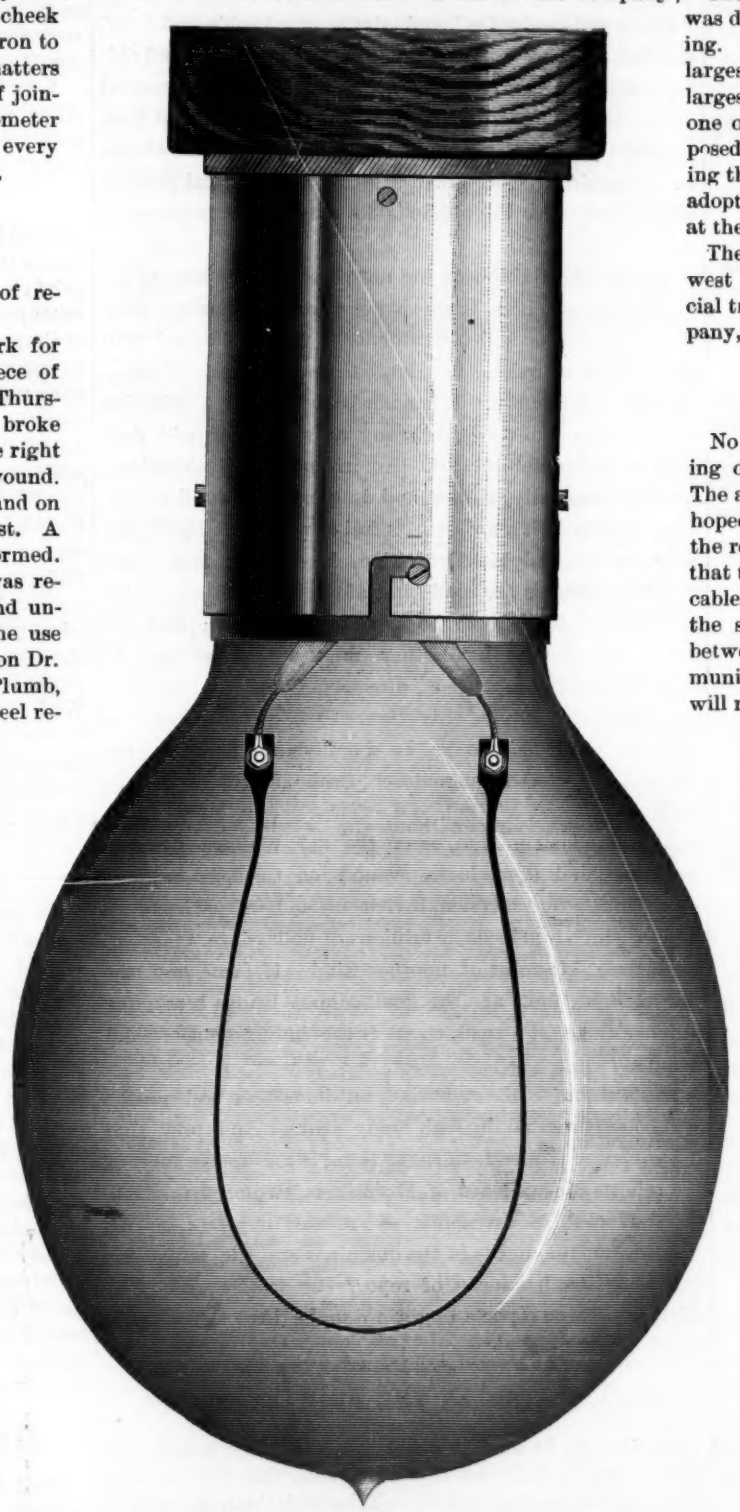

FIG. 3.—WESTON MAMMOTH INCANDESCENCE LAMP, IN SOCKET.

was $7,214,456. The business of the last fiscal year was stated as follows:

Surplus July 1, 1883		$3,658,553.83
The revenues, expenses and profits of the year ended June 30, 1884, were as follows:		
Revenues	$19,632,939.60	
Expenses	13,022,503.90	
Profits		$6,610,435.70
Total		$10,268,989 53
From which there was applied:		
For dividends	$5,599,179.37	
For interest on bonds	472,350.27	
For sinking funds appropriations	39,991.00	
Total		$6,111,520.64
Deducting which leaves a surplus June 30, 1884 of		$4,157,468.89

The total expenses for the year were $13,022,503. The gross earnings show an increase over the previous year of a little more than $178,000, while the expenses show a much larger increase, owing greatly to the telegraphers' strike in July and August of 1883. President Green says: "How much the strike cost the company in loss of revenue can only be estimated, but its cost in extraordinary expenses was nearly, if not quite, $500,000." It is stated that the general policy of the company is to make conservative reductions of rates; and such reductions always result in an increase of revenue within three or four months after they are made. Even the radical reductions stimulated by competition have produced an increase of revenue at many large offices.

After declaring his confidence in the ability of the company to increase its net profits, President Green closed his report as follows:

"Nevertheless, in view of the continuing necessity of extending lines and adding wires to meet the growing demand for leased wires, and especially in view of the probable forced sale of a considerable amount of telegraph properties which may be purchased for much less than the cost of its production, it is recommended that dividends be hereafter confined to the rate of 6 per cent. per annum, and a cash surplus accumulated in the Treasury."

The proposition to decrease the dividend to 6 per cent. was discussed at considerable length in Wednesday's meeting. The reduction was favored by Jay Gould, who is the largest stockholder, and by Russell Sage, who is the second largest stockholder. Mr. W. J. Syms declared that he was one of the heaviest stockholders, and he thought the proposed reduction a very unwise thing. The resolution fixing the annual dividends hereafter at 6 per cent. was adopted by a very large majority of the stock represented at the meeting.

The 20-year lease of the lines of the Chicago and Northwest Telegraph, which was made soon after the financial troubles overtook the Bankers and Merchants' Company, was ratified unanimously.

Cable Notes.

No further news has been forthcoming as to the breaking of the Mackay-Bennett and Gould cables last week. The accident leaves the cable pool six cables, and it is hoped that the "Faraday" will soon be able to effect all the repairs for the Commercial company. It is supposed that the breaks have been caused by entanglement of the cables with the anchors of fishing vessels. Meanwhile the second Mackay-Bennett cable has been completed between Dover Bay, N. S. and Waterville, Ireland, communication being exchanged on the 9th. The "Faraday" will now pay attention first to the broken Commercial cable, and the "Minia" goes from Halifax to look after the others.

A New Mechanical Telephone.

The Empire Telephone and Telegraph Company, Andrew Freedman general manager, has had on exhibition for several days at No. 67 Greene street an acoustic telephone which accomplishes very good results. There is no receiver to put to the ear. A whisper can be heard by the persons at each end of the wire and miles apart. An ordinary conversation over the wire is readily understood by all in a large room, almost as readily as if the conversation were between two persons in the room. The new system announces itself as independent of climatic changes. Notices have already appeared in these columns from time to time of successful tests. The telephone is the invention of Messrs. A. A. Knudson and T. G. Ellsworth, well-known inventors and electricians of this city. The principal part of the invention consists in the diaphragm, which is constructed of layers of braided wood, an imported material that appears to be excellently well adapted for the purpose. After careful preparation, these layers are cemented together and then covered with a waterproof substance, protecting them thoroughly from the influence of atmospheric and climatic changes. Although wood of the proper kind is one of the best of resonating materials, it has not heretofore been used with any degree of success in telephony. It has either split and cracked under strain or its thickness has prevented clear articulation. In the Empire telephone these objections are not met with, as the basket-work diaphragm is flexible. All who have tested the instrument report that it works admirably, even when the line runs two or three miles and is frequently angled.

"A SEA OF TROUBLES."—Francis P. Stevens, of Baltimore, Md., on behalf of himself and such other creditors as may come in, has filed a bill of complaint against the Bankers & Merchants' Telegraph Company, of Baltimore, and the same corporation of New York, asking that a receiver may be at once appointed to take charge of all the property, revenues and assets of the Bankers & Merchants' Telegraph Company of Baltimore city, and an injunction issued to restrain the Bankers & Merchants' Telegraph Company of New York, its receivers, agents or managers from collecting the revenues or interfering with the property and assets of the Baltimore company. The judge has granted the temporary injunction, and appointed Mr. Stevens the receiver of the company. The bill declares that Mr. Stevens is the principal creditor of the company, as it owes him for professional services and money advanced from Jan. 1 to July 1, 1884, the sum of $1,109.90. All of the capital stock of the Baltimore company, except five shares, is owned by the New York company.

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This paper is printed on a Cottrell press, by a Daft electric motor, at the International Electrical Exhibition, Philadelphia.

THE CLOSE OF THE EXHIBITION.

To-day, in accordance with the programme of the directors, the Electrical Exhibition at Philadelphia will close. The success of the Exhibition has probably been quite equal to the expectations of the Franklin Institute and of the exhibitors. The circumstances under which the present condition of electrical industries and applications in this country has thus been exemplified were such as to warrant indulgence in high hopes, and as we look back over the six weeks, from September 2, we see little but cause for congratulation and encouragement.

It was fortunate that a body like the Franklin Institute should be found ready to plan and carry out an exhibition for this country, and electricity as a science and art owes a debt to the Institute for the prominence that has been given it. In some respects, there might perhaps have been better arrangements, and no men would be more willing to grant this than the managers themselves; but as a whole the Exhibition has gone off smoothly, pleasantly and brilliantly, and for whatever success has been achieved, the managers, who worked early and late, and strained every nerve, have chiefly to thank themselves. It is said, and we hope with truth, that the Institute has made a success of the Exhibition financially as well as in other respects. No one ought to grudge it the profit. It has not been earned selfishly, and it will not be spent uselessly. The Institute will treat it simply as a trust fund by which to advance science and the mechanic arts and to give wider scope to its old and noble work. The success of the Institute in the Exhibition is the more notable and praiseworthy from the fact that little help came from outside, in the shape of city or State bounty.

One valuable feature of the Exhibition has been the assemblage within its walls of large numbers of the leading scientific men of this country and Europe, members of the various learned societies. The meetings of the American Association for the Advancement of Science, of the National Conference of Electricians, of the American Institute of Electrical Engineers, of the Telephone Convention and of the Association of Railway Telegraph Superintendents, have been highly important and interesting, and electricians have separated after them feeling that they know a good deal more of each other and of the science to which all are devoting their lives. We esteem it no small thing that on a common platform the best electricians of the two hemispheres have met and exchanged notes and opinions, and have learned to entertain for one another higher feelings of respect and admiration.

The Franklin Institute, adhering to a time-honored policy, has endeavored to make the exhibition distinctly educational in character. Here again it has succeeded. Even admitting the complaint of a few that the public school pupil scheme was a little overdone, and that exhibitors would have been pleased with the attendance of fewer "sweet girl graduates" and rivals of "Peck's bad boy," the fact remains that thousands of people, young and old, have made their first direct acquaintance with electrical principles and apparatus through the Exhibition, and have acquired a thirst that they will never lose for knowledge on the subject. The great sale of the electrical primers shows how eager the public is to master the science for itself.

Though the Exhibition did not present to notice many very great novelties, it was a good, representative collection of apparatus and instruments new and old, and will take its place with the Exhibitions of Paris, Vienna, Munich and London. It has not been without a stimulus to inventors, and no doubt many developments will date back to Philadelphia, 1884. An inventor will sometimes work on languidly, trifling and dallying with an idea that, insignificant as it may seem, is full of potency. Suddenly, as at the Philadelphia Exhibition, he realizes that other minds besides his are exploring along the line on which he believed himself to be a solitary traveler; and the mere knowledge that other men see something in the distance, in that direction, too, is one of the sharpest spurs his inventive genius can be prodded with. Moreover, as the inventor looks on the old homely electro-magnets of Prof. Henry, or on the early telephones of Bell and others, or on Morse's first telegraphic instruments, or on the old Wallace dynamo machines, and then looks around on the 2,500 exhibits representing the electrical inventions and industries of to-day in which hundreds of millions of dollars are invested, he derives a stimulus of another kind. If fame and the desire to be first at the goal cannot bring him more quickly along the road, there is the inducement of solid wealth.

The Exhibition closes to-day, but its effects and results will be experienced through many years. And now that it has come to an end, the next thing is the appearance of the reports of the Board of Examiners, which has made the tests and measurements. No medals or prizes are bestowed, but the merits of the machines and the apparatus will be treated in a series of reports by the several committees. Those reports ought to make instructive reading.

MONEY-MAKING AS THE PRIMARY OBJECT.

Because Mr. D. H. Bates said the other day before the Massachusetts Railroad Commissioners, that the primary object of the Baltimore & Ohio Telegraph Company was to make money, and that he supposed if it could make more money by selling out to the Western Union than by operating it would do so, some critics have jumped to the conclusion that the B. & O. is now "making a deal," and is about to retire from business. This is rather hasty and inconsequent reasoning, and it is to be remembered that Mr. Bates added: "There is no more certainty that the Western Union would eventually control the Baltimore & Ohio than that the Baltimore & Ohio would control the Western Union." Mr. Bates stated very plainly the rule on which most men in legitimate occupations act in regard to competitors. If it is more profitable to sell out than to stay in, they are likely to adopt the former course, and to leave their competitors a field temporarily clear.

But the probabilities of the case being considered, there is no great reason, on the surface, why there should be any selling out, and meantime the B. & O. is pushing ahead actively. Mr. Bates has lately been making a personal inspection of the lines in different parts of the country, and is said to have set his mind on attaining a very exalted standard of efficiency in the service. This the country will be grateful for, and the gratitude will make it more remunerative and profitable for the B. & O. to paddle its own canoe than to take an oar in the Western Union galley. Besides, Mr. Bates said in February of the B. & O. Company that "it is in the telegraph business on its own hook, and very much in earnest."

THE RISE IN TELEPHONE STOCK.

The decision of the Court in the Bell-Drawbaugh suit is not expected for some time, but the hearing before Judge Wallace has been followed by a striking rise in the quotations of Bell stock. In May last our stock quotations showed the stock to be selling in Boston at 150. To-day we quote it at nearly 190, with the promise of reaching 200 in a short time, although just before the hearing of argument begun, it would have been difficult to find a purchaser at 160. The inference is that the Bell case appears to be very strong, and that the supporters of the American Bell Company are confident of success. If the arguments had been prejudicial of the Bell case, no amount of manipulating on the side of the Bell Company could have put the stock up in this way. The "boom" is an indication of the opinion of the public and the stock brokers. It is also due, probably, to the assumption that even an adverse decision would leave the plaintiffs in a strong position, while a decision favorable to the plaintiffs would practically wipe the defendants out of existence.

A decision, one way or the other, will be welcomed by all in the business, to which prolonged litigation has not been very helpful.

PRINTING BY ELECTRICITY.

Speaking last week of printing by electricity, we mentioned that the Lawrence (Mass.) *American* was trying to print regularly by electricity. We are now in receipt of a letter on the subject from Mr. Geo. S. Merrill, proprietor of that paper. He compliments us on our "disposition to be entirely fair" in this controversy that has been forced upon us, and adds: "I just wish to say that we are not only 'trying,' but succeeding admirably. We commenced July 6 printing the daily *American*, a 32-column paper, with power from an electric motor, and the same week, the *Weekly American*, a 36-column paper. From that date, for this purpose, and also to drive three other cylinder and six job presses, we have used no other power. The fires under our steam-boilers have not since been lighted, but each and every daily issue since has been printed by electrical power. Unless your paper is a daily, I believe the *American* is the first *daily newspaper* to adopt electrical power as a constant and permanent power in its printing." We had no idea that the *American* had gone so far and succeeded so well, and it affords us much pleasure to elicit and publish the information. We do not know of any facts to invalidate Mr. Merrill's claim to priority in the respect named by him.

A REDUCTION OF DIVIDEND.

We publish to-day the annual report of the Western Union Company. The enormous earning capacity of the system is seen in a revenue of close upon $20,000,000, and although the annual dividend is reduced from 7 to 6 per cent., the latter rate is high when the strike, new competition, and the water in the stock are taken into account. Dr. Green admits that the great strike cost the Company in extraordinary expenses about half a million dollars, a sum out of which 15,000 operators might have had a bonus of from $30 to $50 each, while the old rate of dividend could have been maintained. It is too late, however, to discuss the what-might-have-beens, and the strike stands as one of the brightest and blackest pages in American telegraph history. There is a grim touch of humor in the paragraph we have quoted from the report, arguing that as some of the new opposition plants will soon come on the market at forced sale, it is necessary that the Company should be ready to buy them up out of its surplus. This is, at any rate, an avowal of predetermined policy.

ELECTRIC LIGHT WIRES IN THEATRES.

Various theatre managers and officials of the Fire Department in this city have been solicited recently to give their views on the desirability of using the electric light in theatres. The opinions expressed are diverse. Some of the managers have a decided preference for electric illumination, and the others who object to it put their distaste principally on the score of bad wiring, this being also the criticism of the Fire Department. Now that the electric light is so much in vogue for theatres and other places of public resort, it is fitting to emphasize the necessity of using every precaution. The Electrical Exhibition, with its thousands of lights, is a good example of skillful and judicious wiring; and what was done there can be done elsewhere. But our observation of the use of the light in theatres inclines us to think that very often managers expect too much and use the light in risky ways on the stage, where the trouble occurs, if anywhere.

A New Electro-Medical Apparatus.—Dr. James B. Williams, of San Francisco, has recently completed a new and improved electro-medical apparatus for removing cancers, tumors, fistulæ, etc., by the aid of electricity, without the use of knives, scissors or needles. It consists of three separate cells, all contained in the same case, which may be used either singly or in combination, depending upon the quantity or electromotive force of current required to effect the removal of different sized growths. The apparatus is supplied with electrodes of an entirely new pattern, for applying the current to external growths, as well as to growths situated in portions of the body where the use of the knife would be attended with danger.

National Conference of Electricians.

FOURTH DAY—SEPT. 11, 1884.

The afternoon session was called to order by Prof. Gibbs, in the chair.

We reproduce some of the earlier cuts for convenience of reference.

Prof. Rowland: With respect to Mr. Thomson's remarks, I am very glad to see the matter taken up in this spirit and to have my principles intelligently criticised. However, there was one remark which I wish to state immediately as an error, of course, with regard to the steel. Steel can be magnetized to exactly the same degree as soft iron. There is no difference between soft iron and steel in that respect, except that you require an immensely greater force to magnetize steel to the same extent as iron. There are some old papers of mine, in 1873, I believe, which were published in the *Philosophical Magazine*, relating to experiments where I took iron and steel and several other metals and showed that the maximum magnetization was the same in all cases, so that there is no difference between iron and steel in that respect.

But with respect to a number of statements with regard

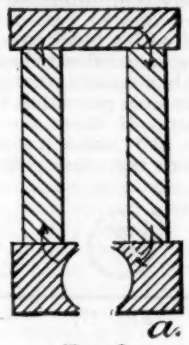


FIG. 3.

to flat magnets and round magnets I am very glad to see my remarks criticised in the manner that they were, because it shows the need of exactly what I stated; and that is experiments upon this subject. The question is one of quantity. My reasoning gave results in one direction, and Mr. Thomson gave reasons for making the magnet in another way, and it is a quantitative question of course as to which is the best; and for that reason I wanted very much to see experiments made in a manner which I have described, and by no means in this magnetic proof way, so as to find out what the escape of the lines of magnetic force in all cases is.

I think we can decide on one point that was brought up, without any trouble, and that is with re-

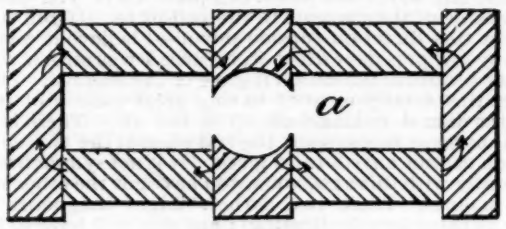


FIG. 4.

spect to the dynamo made in this manner (Fig. 4), where it was assumed that this magnet sent the lines of force down here and that they cannot go around this way. In other words, it was assumed that the lines had a tendency to go in a particular direction, and that this was a sort of gun shooting the lines of force through the armature. That is not true because they do not have any tendency to go that way at all, and you would only add that much to the area of the end of the magnet. Very few lines of force will go out there, and by putting this on you add to the area of the magnet. The lines of force will go out at the sides probably in greater numbers than they would at the end, so that I do not think that particular objection holds in that

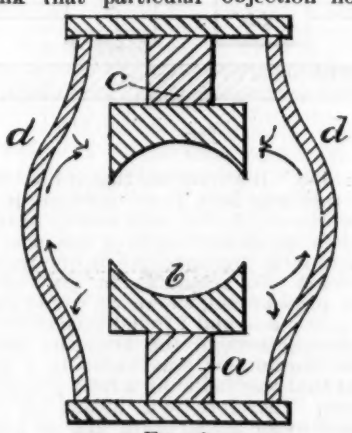


FIG. 6.

particular case. It is a question of quantity, the thing should be measured and found out. But I see very plainly in my own mind that more lines of force would go out the side of this thing by adding this iron here (*a*, Fig. 4) than would go out at the end of it by leaving it vacant. Therefore I would prefer to have one circuit in the place of two. I believe more lines of force escape here (*a*, Fig. 4) than in the other cases, but it is a matter of mere opinion. If there were more here (Fig. 3) I do not think that would make up for having four magnets in the place of two. By having two magnets there is less surface for the force to escape than there was before. That is another reason for having fewer magnets. The surface is greater in the case of the larger number than of the smaller number; there is more surface for the lines of force to escape.

With respect to the other form of machines, I do not wish to get into a discussion as to these little points, but there is one point brought up here upon which I would like to make a remark, and that is with respect to the machine which was made this way (Fig. 6). It was stated that there was some gain from the magnetic action of this coil on the outside. There is undoubtedly a gain—the question is, how much? The question is, whether more lines do not escape than would make up for that; and, if you have no experiments to go on, it is a case of judgment. My own judgment would be that there would be very little gain; but, as I said before, the thing should be measured up, and then we could find out about that point. There are other points I could mention, but I will not take up the time of the Conference.

Mr. Keith: I have drawn upon the board diagrams by which I may illustrate the evolution of a machine that is at the Exhibition; and I will begin by the following description: Suppose Fig. 14 to represent two closed magnetic circuits, placed so that their polar ends are in juxtaposition; then there is no external induction; the magnetic circuits are complete. The magnetic current lines may be said to circulate in the directions of the arrows. The magnetic potential, then, if the mass be properly distributed, is the same at all points.

Now, according to the theory which is very well accepted, if we cross any of these magnetic current lines by wires we produce in these wires currents of electricity flowing steadily during constant motion. As soon as we make a space here (*A*, Fig. 15) in order to produce evidence of these lines of force, we introduce greater resistance to the magnetic lines, and the tendency is for a majority of the lines to cross from pole to pole, but others distribute themselves in various curves according to well-known laws. If we take this mass of metal and place it back again, and if it exactly fills the space, we by this act again close the magnetic circuit, and there will be no external indication of the field. Of course it will not be possible to pass wires between such surfaces; but, by taking out the core and turning it so as to make it smaller to admit of the passage of the wire completely around the core in this space (*B*, Fig. 16), we will then obtain the highest possible efficiency of field under that construction of the magnet and armature. If we then take this core and cut it transversely into a mechanically desirable number of discs and insulate them to prevent the formation of Foucault currents, we will then have a practical magnetic core, upon which is wound a wire of dimensions that fill the space between the core and the poles so constituted; and if this armature be rotated, the wire being connected with the proper collector, we will have the highest possible concentration of the magnetic force of these two magnets.

Of course, mechanically we cannot bring these surfaces into contact. We must allow room for the movements to take place, so we will let that space *B* be as narrow as possible. The result is then, the highest mechanically possible efficiency of the machine for the production of electric current. Furthermore, the greatest concentration of magnetic lines of force on this armature is upon the diametrically opposite points as shown by the line *x y*, (Fig. 16.) When this armature is rotated the currents are gen-

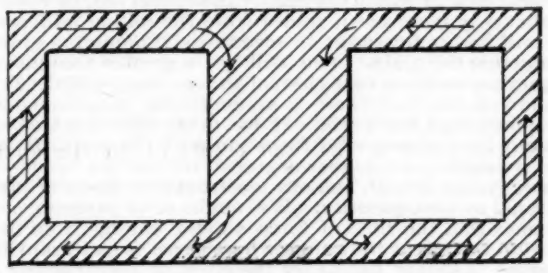


FIG. 14.

erated in the coils which surround it. The currents are taken off at points 90 degrees removed from the line *x y*, as at points *a* and *b*. The tendency of these currents is to magnetize the armature, so that the poles of the armature will be 90 degrees from the poles which are induced in them. If the space is considerable and there is not enough magnetic material of the core of the armature within the coils which surround it to make a complete closure of the magnetic circuit, there will be a distortion of the poles generated. In other words they will be moved forward by reason of the counteracting forces of the magnetic induction and the electro magnetic effect upon the core of the armature. But if this armature has been made as nearly mechanically perfect as possible, and the current which plays around it does not exercise a dynamic effect upon the core sufficient to distort the magnetic poles, there will be no necessity under the varying circumstances to which dynamo machines of constant potential are submitted, to move the brushes in the direction of the rotation.

This desideratum is obtained, it strikes me, by the machine referred to and with a very high degree of efficiency on that point. As practice always best illustrates a theory, I will state that I have seen one of these machines capable of supplying 200 incandescence lamps. One of the lamps being placed from binding post to binding post, 199 of them were switched off instantly. The remaining one at the binding posts, as nearly as I can form judgment by the eye, (the others being out of range of the eye so as to avoid an error of judgment on that point), was not raised more than 5 per cent. in illuminating value. These machines show very nearly constant potential. There is no necessity for removal of the brushes to compensate for varying resistances in the external circuit.

It seems to me that a machine so constructed satisfies as nearly as mechanically possible the theory which seems to be most generally accepted, and that there are various points which might be stated about this machine as illustrating some of the points which have been brought before this meeting. One of them relates to the association of two magnetic circuits, producing what we call consequent poles. I understand (though I cannot speak from knowledge on this point, but I believe it) that when two magnetic circuits are placed in this relation, the tendency, or the result, is to concentrate the lines of force upon the true magnetic line, or the true line of division of these magnetic influences. Certainly the practical facts point to this—that where only one magnet is used there is, under the laws governing the location of poles of magnets and distribution of magnetic lines, an entirely different field from that which exists under an association of magnets. There is a greater tendency to increase the magnetic strength of the points, or horns, as will be found by magnetic exploration. It may be that if the armature be proportioned in all respects to the field after the manner I have here shown that there will be a difference in the distribution of lines of force. They certainly will approximate better to the theoretical points than they do in some machines now at the exhibition.

Prof. Silvanus Thompson: Mr. President and gentlemen: I have a few criticisms to make upon some of the methods that have been brought before us this morning, and I propose also to intersperse my criticisms with some remarks of my own as I pass from point to point. In the first place I wish to refer to the matter which Prof. Fitzgerald brought before us of the apparent or spurious resistance caused in a rotating armature by the self-induction of the armature coils. The way in which I have looked at the matter is very slightly different from that of Prof. Fitzgerald. I want to correct his formulæ in one respect. He wrote the product of the number of sections of wire into the self-induction per second into the square of the current of the machine. That is not the most convenient way of writing it, because we must remember that although there are two ways around the armature from brush to brush there is only one for the current in any section of the armature. If we want to treat the resistance in the path of the circuit we must remember, letting n be the number of revolutions per second and L the coefficient of self-induction of the armature entirely around, and writing i instead of C for the current, as I always do, that we have to take the square of ½, so that we have $n \frac{L i^2}{4}$

Prof. Fitzgerald: (Interrupting.) Will Prof. Thompson remember that I used the sign of variation instead of the

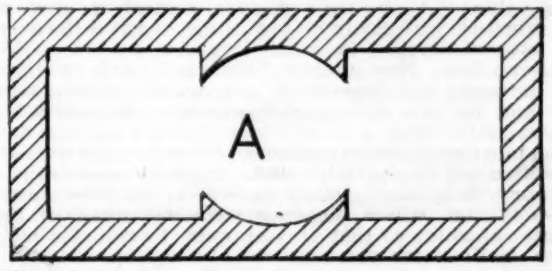


FIG. 15.

sign of equality. You are right in saying that it should be "variable as." I was particularly careful not to write "equal."

Prof. Thompson: I want to be able to put it into Ohm's law and write the current is equal to that, whatever it may be. I will write it down; I think it is right

$$i = \frac{E}{R + \frac{n L i^2}{4}}$$

Professors Edmund and Barrett, when they published this matter on electro-motors, actually said, if you make the experiment and calculate this out you can express the self-induction in ohms. I could not help thinking when I saw that, that there was some mistake in calling a coefficient a thing which could be expressed in ohms. I find that self-induction is a length; and in absolute dimensions resistance is a velocity. There must be something more than what Professors Edmund and Barrett wrote. The fact is if we cross out the i^2, we shall have the true apparent self-induction. Suppose we write E for the electromotive force, and i for the current. Then that equation may be written as the sum of the number of other things. The work of the current is measured among other things by the work done in overcoming the mere statical resistance. So that we have to add the work done in overcoming the work of building up the intrinsic energy of the current, or its self induction, which gives $Li \frac{di}{dt}$. To that we must add the work done in increasing the current in the field $n \frac{di}{dt}$ and to that we have to add $i \frac{dn}{dt}$, if the field varies. Neglecting these last terms, which relate to the external field, which we may suppose to be constant, we see that this term might be

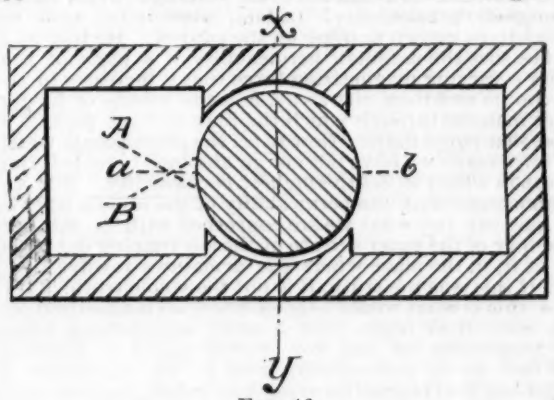


FIG. 16.

written along with that one as a spurious resistance. If we take an integration for any length of time, and in this case we simply cross out our *ds*, and we shall have virtually $\frac{Li^2}{t}$; that is to say, the self-induction, divided by the time, may be in the nature of a resistance, then we have virtually the velocity.

If we have the value of the spurious resistance for any velocity, we can measure it for any other velocity, and therefore we can make a correction for different speeds of driving our machine, at once knowing what it is for any given velocity. L is the coefficient of self-induction for the whole armature, and it makes no difference for the value of that n how many sections the armature is divided into. I will not call attention to the effect on self-induction of dividing up the armature into several sections.

Now comes in an important point where the actual waste comes in. It is not in the fact that the self-induction sets up for the moment a spurious resistance; that makes it go like a smaller machine. The waste comes in when the coil is short circuited. In an ordinary commutator of the Gramme or Siemens type, that coil is short circuited, and it is then no part of the circuit of the dynamo: it is a neighboring circuit, and we have

no right to talk about the self-induction, we must consider the current apart, on the separate circuit, which is closed in itself. It is there that the waste occurs. The current is running around this little circuit closed in the coil and heat is produced; and I hold that it is absolutedy wrong to put two brushes at the top, one in advance of the other, to kill the spark, because you prolong the motion of the coil during which this deleterious action comes into play. You may notice the spark which is caused by the local current running around from one brush into the other through the coil that is short circuited.

Again, if we pass from this subject to the more weighty consideration of how the self-induction term is related to the machine as a whole, we may write for the electromotive force of the machine, $E = 4\,n\,A\,H$. That is the form in which I have written the equation of dynamos in a book, the proof-sheets of which I hold in my hand, which I have written, and which contains a theory of the dynamo. The number of revolutions per second is n. I have used this letter instead of ω, the angular velocity, because I thought it was more suitable to have the number of revolutions than the radiations per second. A is the effective area of the armature coils. You have an armature consisting of one turn of wire, and, as it turns around, it will cut a certain number of lines of force. Everything depends upon the area of the field. If the coil consists of more turns it will give a bigger area. If you had iron in the interior of the magnet, from this equation you would again find a certain larger area which would have the same effective value. A is the effective equivalent area of the armature with many or few turns, and H is the average value of the field in which this armature is supposed to be rotating. Now which of these terms is it on which self-induction will depend? If you run the machine very fast and increase the quantity n so as to get quite a big electromotive force, you will increase the quantities that come into that spurious resistance. You increase the self-induction and the spark troubles. If you increase the area of your coils by having many more coils, you increase the self-induction, which increases with the square of the number of coils; so that if you want to run at a high electromotive force you must run at a high speed and not have many turns on your armature. The only way in which you can do that is to have a very strong field, and I believe that the true progress of the dynamo for the next twelve months to come will be in making the fields of our dynamos so immensely strong that we shall not have to have very many turns of wire nor have to run at an outrageously high speed. If we succeed in getting strong fields, we need not have so many turns and we can run at a low speed, which is eventually better. We gain immensely by this, because there are other things besides sparks that come into play when we have high speed, by reason of the complicated brushes. There is the question of lead, for example, at the brushes, which was alluded to by Mr. Keith.

Now we come to the remarks of the President when he opened this discussion. He spoke about the shapes of magnets. I have made the remark in my lectures that circular cross section should be the best because a circle has the greatest area with the least perimeter. But in practice for very large machines a circular form is not the very best form. If we take a circular cross section for our pillar of iron, the iron at the middle is so far removed from the coils outside that it does not, at any rate so soon, get magnetized as the iron at the outside, and, what is worse, the magnetism actually turns around inside and short circuits itself through the interior. If you will take tubes of iron, one outside of the other, and then magnetize them with a coil on the outside, you will succeed in magnetizing the outside one, and some of the inner ones; but the innermost ones are not only not magnetized, but you have them magnetized in the reverse direction in some cases. I have tried it. (Applause.) Again, we find if we take a very thick bar of iron and magnetize it by means of a coil and examine how the magnetism increases when we increase the current, and plot out a curve showing the relation between the two, we do not in general get that which we ought to get if the magnetic permeability were what it is always found by high theorists to be. Let me explain that I have the greatest admiration for the work Professor Rowland did some years ago on this matter of magnetic permeability. In fact, without his work we should have known nothing on the subject. He told us if we measure the magnetic permeability of a piece of iron under a varying magnetizing force that it increases to the maximum and then dies away, and the effects of having other material through which the lines of force pass, is to make that curve flatter. Now in all the experiments which we have made we have not got an absolutely welded ring of iron in which to get the highest permeability. Nor are we concerned with the permeability of the middle body of the long bar; but what we are concerned with is the permeability of the outer surface of the bar running out to the end of it, in the place where the armatures revolve. In fact, if this was the truth, it is not the whole truth. If it were, this is what would happen when we magnetized our iron bar. If we began with a small magnetizing force, the magnetism of the bar would begin to increase, and then as its permeability rose to the maximum it would begin to magnetize more than before, and our curve of magnetization would turn up more sharply, and when we got to the maximum it would begin to go on as it did before and finally approach a straight line. Now the curves of magnetism we get with thin bars never, except in large masses, show the reversal at this point; they rise practically in a straight line from the origin and then turn over and approach their limit. The characteristic curves of our dynamo machines, neglecting self-induction, are exactly the same thing. Plot out the electromotive force at a given point of the diagram. The characteristic curves of our dynamo machines do not, except the machines have very large masses of iron in them, show at any time a hollowing in the curve; they rise. The magnetism of iron in the so-called unsaturated state is proportional to the number of turns of the wire on the magnet multiplied by the current running through it; and its curve runs up straight and then turns around, and our magnetism begins to be got only at a higher price. By doubling the current you no longer get double the magnetism. The very fact that we do not get this hollow in the curve shows us that there is something wanting, that it is not the whole truth: that the real susceptibility of our copper or iron circuit will be something more like this (indicating), that it begins practically at a certain value and keeps on from that value until it begins to turn and then comes down.

When everything is saturated, it can be magnetized no more than ice can. The figures which Prof. Rowland mentioned were something like a thousand or two thousand. This has been surpassed by an experiment of Prof. Ewing in Scotland, who has given us figures like 5, 10 or 15 thousand. But such numbers do not express in the least degree the increase; we want to express the permeability of our magnet as a whole. It is nothing like that; it is more like twenty or thirty thousand we get. It is true as to the permeability of a bar of iron that you may be able to stuff magnetism into it from end to end, some of it leaking out at the sides and coming out of the end. You may magnetize it through and through until that central body shall be magnetized to that extent, the permeability being five thousand to the square centimeter, or something like that; but you do not get that from the bar when the armature is being revolved.

I was talking with Prof. Hughes concerning experiments on the multiplifying effects upon a bar of iron of putting it into a coil. The experiment was tried something in the way of Rowland's method, but the results were not the same. He took a coil and put a core inside of it, and laid it upon a board which had a magnetic needle at a certain distance. He had then an arrangement to find out the magnetic effect on this needle. He tried both iron and steel cores. When he put in an iron core of the softest Swedish iron, he found that it did not magnify the effect on the bar more than eight times. He did not mean that the permeability of the iron was only eight, but that the permeability of that circuit as a whole was only eight. The circuit was a complex one. He considered the whole effect of the air, and the piece of copper wire, and the permeability of that circuit taken as a whole was only eight, instead of five thousand or twenty thousand. We want a great deal more of magnetic experimenting on circuits of which only a part consists of iron. We can deal only in a practical way with this matter.

There is another matter that has not been dwelt upon—the effect upon the magnetic energies of the iron, due to the grain of the iron. I believe we are only beginning to realize the importance of employing wrought iron instead of cast iron in the building of dynamos. I might mention that Mr. Crompton, of England, who employs a dynamo of that type which has been so beautifully abused here to-day, has succeeded—without any other change except merely substituting, for cast iron, wrought iron, chosen so that the grains should run in a proper direction, having the same machine, the same armature, the same number of coils, and everything alike except the qualities of the iron—in getting an increase of one hundred per cent. in the circuit of his dynamo. That is, it worked as a machine of twice the capacity. He doubled the power of his machine by merely changing the quality of the iron. We all know it is easier to magnetize a bar of iron according to its length than in any other way—that is, to magnetize it along the grain. Try an experiment on a piece of wrought iron in which the grain can be observed, or notice in what way it runs as it comes from the rolling mill, and you will find it far easier to magnetize it along the grain than across the grain. You will get a greater amount of magnetization from that piece of iron so magnetized. Try it, and you will find there is an enormous importance in this question of the grain. If we magnetize the iron so that our lines of magnetic force run with the grain of the iron, we shall get a higher degree of magnetism inside—a greater value for H, and our electromotive force is proportional to that quantity. We ought so to arrange our dynamos that the lines of force should emerge from the iron into the air at the points where there is end grain in the iron. I should like to try the effect of constructing a dynamo with a double or single pole at the top where the iron is so turned that the grain points in each to the place where the magnet was to be; I believe it would give a better effect.

In this book to which I referred I deduce a large number of equations for different types of dynamos, and I am going to trouble you with two simple ones, because they bear upon this question of the energy and quantity of iron in the dynamo. I am going to write out the two expressions I obtained for the electromotive force of a series machine and a shunt form of machine respectively. The letters are the same in each case, except that S is used for the number of turns in the series machines, and Z for the number of turns of wire wound on the shunt. R is the resistance of the armature; n is the number of seconds; A is the same as before; G always goes along with K, and is a purely geometrical coefficient, depending upon the shape and size of the iron masses of the machine. K is the magnetic permeability, what Prof. Rowland has designated by μ (or π, in previous report of proceedings).

Before I explain I will write down the two equations, the first for the series machine, and the second for the shunt machine.

$$E = \tfrac{1}{\sigma}\left(4nAGK - \frac{R}{S}\right)$$

$$E = \tfrac{1}{\sigma}\left(4nAGK - \frac{r_S r_a R r_S + R r_a}{R_Z}\right)$$

The resistance of the shunt is denoted by the r_S; the resistance of the armature by r_a. You will notice that in the second equation we have virtually the conductivity of the machine as a whole in the numerator of the fraction, instead of the resistance.

Now this factor $\frac{1}{\sigma}$ comes in both equations. I have taken σ to represent the permeability; and I am going to assume that the permeability does not rise in this kind of a construction as it may do in the middle of the piece of pure iron. Practically it is constant for a time in respect to the whole circuit, and then gradually diminishes. The value of that permeability when the magnetizing current is varied diminishes from its original value, and the law of its change may be represented. I do not say this is the true law, but it is one that practically meets the facts of the cases most beautifully, namely, $\frac{K}{1+\sigma Si}$ only if the current increases and becomes very large indeed does this second term of the denominator become of value. If we multiply this by G, a geometrical co-efficient, and by S, the number of turns, and by i, the current, that quantity may be held to represent the average field. It is proportional to the permeability depending upon this quantity σ.

What is this quantity σ? In examining what that means let us plot out once more the curve of magnetism, or electromotive force, neglecting the inductive effects. We get a curve which rises, and then turns over. If you will find out what σ means, it means this: If that iron never got saturated, the magnetism would go on increasing and stop at a straight line; but it diminishes, and there comes a time when the magnetism is one-half what it ought to have been if the iron had remained unsaturated. There are a certain number of ampère-turns here. The field of our magnet will have so far saturated with magnetism that it will have only one-half the permeability that it had when we started out. When you have got to that point you have a very large number of turns. σ is the reciprocal of that number of ampère-turns which, for all practical purposes, will reduce the iron back to one-half its permeability. The number of ampère-turns which will do that is the reciprocal of σ. If, therefore, we have very good iron indeed, and plenty of it, so that it takes a tremendous number of turns, then we shall have a very large electromotive force when such iron is used in the dynamo. It is most important to note that the effective power is practically proportional to that quantity which reduces the magnetic susceptibility of the iron. With this criticism that this theoretical curve, true as it is for its own circuit, is not true for such circuits as we have to deal with in dynamos, I shall dismiss that point.

I have more than once criticised the use of multiple magnets or poles. There are some machines I forbear to mention, in which there is an immense block of iron used for a pole piece, then one or two other pillars of iron separately magnetized with a block to contain them on the other side. Those are scientifically bad, not only for the reason Prof. Rowland has named, that it takes more wire to run around than one solid piece, but for another reason. Let us look at the figure. If these are all going to magnetize the pole piece and make a north pole, and if in looking at it these were the south poles ($A\,A\,A$), the currents from the first pole will run down (arrow) and from the second one will run up (arrow); and in between the two pole pieces these currents are absolutely hindering one another's magnetism, and it would be far better to wipe out the currents there altogether. Therefore we gain in work by running the two into one, because we are not employing part of our current to destroy what another part is doing where these turns come in there between two pieces of iron in opposite directions.

FIG. 17.

We ought not to forget that mechanical considerations are quite as important as electrical ones. Take the case which our president put upon the board. He seemed to think that a field magnet was far better as it was, without doing another thing to it. I do not agree with him. In the first place this structure (Fig. 3) is a big piece of iron up in the air, and if you put a bed-plate there you short-circuit some of the currents in the bed-plate. If you turn it up in this direction (upside down)—I believe it was in that way our president drew it, because I was struck with the very beautiful indication it gave of the leakage. I did not like that arrangement of having great masses of iron vibrating like a tuning-fork up in the air. There is no reason, because you support the bed-plate at the two ends, that you cannot have a third piece. It is not symmetrical, bi-laterally with this axis, when you have got the other side to the magnet. These two corners might magnetize as strong as these two (indicating); and you will have to cut them away in one place or the other in order to have an equality of the field bi-laterally with respect to the line I have drawn.

We had another drawing of a machine, in which I quite agree with the criticism passed by our president, and it struck me as being really a remarkable thing that no exception had ever been taken to this machine before. It is a machine which had one pole piece above, and one below, and two Gramme rings, one here and the other there in between (Fig. 8). I have heard that called, I believe, a

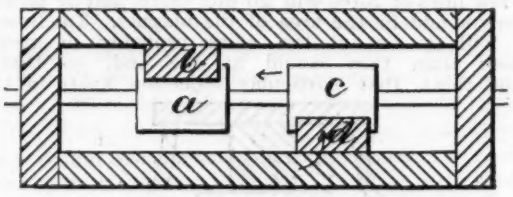


FIG. 8.

uni-polar machine. It strikes me that it has two poles. I cannot help thinking that that machine is altogether bad; it may work; the fact is, it is hard to have a dynamo machine with a Gramme ring in it that does not work. But I have examined this machine in one respect: I tried to find out what was occurring in the vicinity of the armature and piece of coil, where we would naturally expect another pole piece; and I found this: the very current which was running through the armature and over the brushes to the commutator was inducing a pole in the armature, and that was inducing a false pole in the piece of iron opposite. Therefore by no means all the lines of force that ought to go across there did go across. They spread out into the air. I examined this machine once in England, and I saw a similar machine in your exhibition, and it seemed to me as a striking commentary upon it that over that machine was a sign which ran, "Do not approach this dynamo, for fear of magnetizing your watches."

I do not think that this curve of susceptibility represents the whole truth, because in our dynamos we cannot deal with iron at one constant temperature; and the susceptibility of iron changes so much with the temperature that no dynamo can be considered at all complete that does not take that into account.

I want to refer to another curious point which no one has publicly stated anywhere, and of which no explanation has been given. Take a Gramme dynamo—these here, say, are the pole pieces (Fig. 18); and it is run in this direction (arrow). If no current were being taken from the machine you will have induced poles; if there were currents taken up from the machine to be used, there is a resultant north and a resultant south (N. S.); they are the effective poles of the machine in action. I have shown elsewhere that the ratio of the two fields due to the field of magnetization and due to the current is proportional to the sine of the leaning. When these poles are so disposed—and that is the actual way they are disposed—the pole is

displaced forward, and strengthens part of the magnetic field ; yet the effect is comparatively weak.

Now, there is another thing I want to refer to. In a Gramme machine which has been running for some time the ordinary effect is that that corner and that corner (*a* and *b*), get hot, and the other corners are comparatively

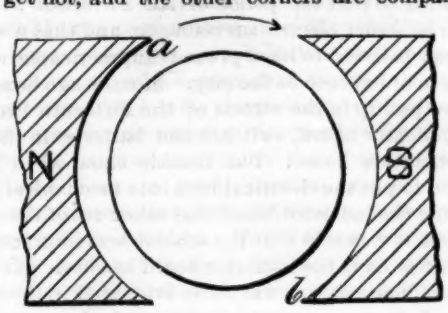


FIG. 18.

cold. In order to explain that curious fact observed by Cabanet, when I was last in Paris he told me, and he is able now to verify the fact, that he took one of these beautiful laboratory Gramme machines, with the magnets like a horse-shoe, and used that as a motor. After a while he found the field magnets going down in strength. After having spoiled it in that way, he used it as a field magnet or generator, and he found the magnet coming up again to very nearly the original value. I thought it was imposible; the fields respectively due to the field magnet and the armature current absolutely help one another in a motor; and in a dynamo they oppose one another. I do not know how much they hinder one another in a dynamo, but to some extent the lines of force cross. There would be no electrical work done as work in the circuit if they did not. How can we explain that the helping field of the motor absolutely de-magnetizes the magnet, and the working field of a dynamo absolutely helps the field magnets? The one observation I made which connected these two is the following: I have not published it yet, because I am going to try it with a larger number of magnets; I have only done it with two magnets as yet. Suppose you take a horseshoe magnet and an armature of iron with a hook on it. You can purchase such instruments of the maker, who will probably give you instructions never to pull the armature off suddenly for fear you will upset the magnetism. They could not possibly give you worse directions. If you will take a magnet and try what the effect is, fasten it down on a board with brass screws and fix a magnetometer near it, to see how much it pulls the compass around, and draw it slowly to its proper position and suddenly drag it off, you will find that the magnet grows stronger. Do that twenty times and you will make it considerably stronger. I have made a magnet twenty per cent. stronger by putting it on very slowly and pulling it off suddenly. If you will reverse the operation and pull it off slowly, you will find the magnetism will go down. I have made magnets diminish ten or twenty per cent. in this way. Why does this occur? It explains both these effects. If you take away a piece of iron from a magnet, you do work against the magnetic attraction and the induced currents which are set up in the iron or steel of that magnet are always in such a direction as to oppose the motion, that is to say, they make the magnet pull more strongly than before. We magnetize the magnet more strongly. In the reverse motion there are induced currents which occur when you allow this armature to slam up, which are such as to oppose the motion of slamming, and decrease the magnetism. You can magnetize more highly by suddenly pulling off and putting on quietly. That is precisely what is occurring in the field here when this machine is used as a generator. This horn (*a*, Fig. 18) of the pole passes here where currents are being generated during the passage. You are pulling off the armature, and you get heat here, because of the induced currents. This explains also how when used as a motor the magnet is weakened, and when used as a generator the magnet is strengthened.

Prof. Rowland: I have listened with great interest to this discussion by Prof. Thompson. I have only one point. I am the defender of two theorems with respect to the machine, and that is with respect to round magnets and the simpler circuit. With respect to the round magnets I may state that I was very much astonished, indeed I can say astounded, at the remark of Professor Thompson that the magnetic force in the centre of the round coil was not the same in direction as at the surface. Indeed it is so revolutionary that I should imagine that it would produce such an effect on the scientific world as would a demonstration that the law of energy was not correct, or that gravitation did not vary inversely as the square of the distance. Therefore I must strongly dissent from that. I do not think the matter can be discussed. If anything further is said on it, it must be in the way of a scientific paper which will take up the subject, and make a grand sensation in the scientific world.

Prof. Silvanus Thompson: My reasons are that I had taken concentric tubes and put them outside each other, and then magnetized them and found that the magnetism of the inner ones was reversed; so that if my experiment showed anything, it showed that the internal pieces of iron were reversed in magnetizing.

Mr. Keith: I desire to say that I tried that same experiment, and published the fact, not as my own determination, but in answer to an inquiry in THE ELECTRICAL WORLD some three or four months ago; not claiming it as my discovery, but simply as an observation that had been made.

Prof. Rowland: It only requires a moment to see what the real cause of this is. It is perfectly evident. Suppose you had a tube like that, with an internal piece like that. You magnetize with a coil on the outside. The lines of force have got to get to the outside and then go through to the central piece here. From the outside piece they have a complete circuit around, so that when the experiment is carried out in this way of course the outside piece will be magnetized more than the centre. But when you bend them around, so that the two ends come together, it is equally easy for the magnetic circuit to be completed through the centre as well as on the outside. You can join this up and not have an opening at all, so that the lines of force could go around there. It is the same: it is merely a matter of tracing the whole circuit.

Prof. Forbes: I venture to say that even in this case the magnetism of the central rod could not be the reverse of the outer tube. From what Professor Thompson has said I think I know the whole difficulty. He has magnetized his tube and then taken away the magnetizing force, and afterwards tested it. It is perfectly well known that magnetism may be reversed in that case. De la Rue showed that in 1836; it is in his book. But as long as you do not take away the magnetizing force it is not so.

Mr. Elihu Thomson: I remember reading an observation which bears on this subject. I think it is by a German physicist. He states that where you use a broad, large coil of large diameter, and put a short piece of steel in the interior, that, singular to state, that piece of steel becomes permanently magnetized in an opposite direction from what you would suppose. Whether it is so or not I do not know. I thought at the time that perhaps the explanation might be found in this manner: That treating the magnetic field as a closed circuit of lines of force, the very great density of magnetic force in the wire may at times recoil on itself and close through, though that seems to revert to the influence of the magnetizing coil in its action.

Prof. Silvanus Thompson: Prof. Houston has recalled to my memory what I had forgotten, that quite recently Mr. Hughes made some experiments on the concentric tubes. He magnetized them, and then dropped them into acid, and found the insides of the tubes were reversed.

Prof. Anthony: I would like to say a word with regard to one or two of these points. As I understand Prof. Thompson, his statement was with respect to the use of the flat core of this section in place of a round core containing the same quantity of iron, and that in the case of a round core it did not require the same amount of magnetization. I should like to know if I am not right in supposing that it was demonstrated long ago that the interior of a round bar of iron was of very little advantage to the strength of the magnet, and we may take out of the interior one-half or two-thirds of the diameter, and retain about the same strength of magnetism in a bar as though the mass were a solid bar. Am I right in that view?

Prof. Rowland: Yes.

Prof. Barker: Prof. Mayer said that the thickness of the shell need be only about one-twelfth of the diameter.

Prof. Anthony: Now then if the mass of iron be flattened down so as to make it very nearly in the centre the result is obtained of putting a large part of the iron in the position of doing the best work.

But what I wanted to speak of in this connection is an experiment that I tried several years ago with a Gramme machine, which was constructed at the Cornell University, illustrating this fact of the self-induction in the machine. We constructed there a machine having a Gramme armature, with the alternate coils connected to the commutator on one side of the machine. The other alternate coils were connected to the commutator on the opposite side. So that you understand that the coils connected with one commutator are sandwiched in between the coils connected with the other commutator. Now, in one arrangement of the machine, the brushes connected with this commutator could be so connected with the field magnets that the field magnets were thereby rendered magnetic, the other side of the armature being used at the same time for producing current for the outside circuit of the machine. Now, supposing this to be used for exciting the field magnets, on closing the circuit by means of a wire of very little resistance, the machine became short circuited; in fact, the whole magnetism of the machine would run down in about one-fourth of a minute. I could explain it in another way than that, as these coils were passing the neutral point, and the current in the various coils connected with this armature—this current was, of course, a very great current in consequence of the machine being short circuited—as these coils passed by the brushes and the current is reversed in them they react so strongly upon the coils connected with the other side of the machine with which they are in close juxtaposition that they completely destroy the current which is in the magnet and run down completely the magnetism of the machine. That self-induction, of course, must occur as the machine is in use the ordinary way with all the coils connected up. It amounts to the same thing. Prof. Thompson says it is mutual induction and not self-induction. But each one of these coils acts upon its neighbor in the same way, as I understand it, when it forms a part of the same circuit.

Prof. Rowland: I am very glad that that point of hollow magnets has been brought up, as I think that it causes more difficulty, especially to practical men, than almost anything else; the question of hollow lightning rods and a great many other things. I think it can be explained in a very few words. Suppose you have a hollow bar having the magnetized coil around it acting to send lines of force along it in this direction. (Indicating.) They have got to have access to the air; they have got to go out to make their complete circuit. You cannot have them end at any point; they could only end at a certain point if we had free magnetism, that is, a separate magnetic fluid. I speak not from a physical sense, but from a mathematical point of view. If the iron is solid they go around in this way; we can trace them out. The principal resistance to the propagation of these lines of force is in the air outside, and not in the magnet; and even if we take away a large portion of the interior of that magnet we will have the surface the same as it was before, and consequently the external resistances are the same. We have taken away the inside which was not needed. Therefore in such a case as that if we remove the internal part we leave the magnet about as strong as it was before. But that would not be the case if we compressed magnetism into that until we get it up to the point of magnetization of the centre-piece. In that case we should need the whole mass. It is almost impossible to magnetize to any extent without finding a point in which the centre comes in, even with a moderate magnetizing force. It depends on the length of the bar. If you bring the bar around, making a complete magnetic circuit of the thing so that the lines of force do not have to pass out into the air at all, when you put a wire around it so as to wind it like a ring at every point, in that case the whole cross section becomes equally magnetized, if it is not bent too much. If it is a large ring of small cross section, it is perfectly magnetized across from side to side. We know that perfectly well; it is a law of the conservation of energy. It is nearly uniformly magnetized across. The case of dynamos is like that. We require the whole cross section to transmit these lines around; here (indicating) they pass across this opening. The resistance to the magnetization comes partly from this opening and partly from the iron. We have no gain in making these cylinders hollow; indeed, we rather increase the outside forces and let them flow out into the air. In the case of a dynamo machine, the solid form is not only desirable, but by far the most efficient.

I am very glad this point came up, because perhaps you will get the idea of how I think upon that matter. I have thought of that matter a great deal, and experimented upon it. Indeed this closed circuit is the very idea from which the permeability of the iron is determined; and in determining that you have of course to calculate the cross section. All the calculations upon that subject are based upon that law. I think there can be no doubt that in the dynamo the solid form is the proper form, and that the whole cross section is effective. The whole cross section of a round piece is just as effective as the whole cross section of a flat piece. The flat piece exposes more surface to the air and there is more surface for the force to escape from. That is another reason for not making the magnets flat. The round form is that in which there is the least surface, and therefore the least liability of the lines of force to escape. You can conduct the lines of force by a round piece to any point you desire much better than by a flat piece.

Prof. Silvanus Thompson: I want to call Prof. Rowland's attention to another matter connected with this question of very heavy solid iron cores, that perhaps he may not know. There are certain objections urged by practical electricians to the use of these very heavy iron cores which come from quite another source. It is that the machine takes such a long time to charge itself with magnetism. It takes a certain time to magnetize a solid magnet. I have a large electro-magnet in my laboratory, and it takes the magnet ten minutes to get up to its full speed when the magnetism comes into play, owing to the slowness with which it takes up magnetism. That is held to be an objection; it is objected to by those who want to build self-regulating dynamos in which the magnetism is required to change the magnet instantly. If we want to work partly with shunt and partly with series, however perfectly you balance the number of turns of wire you do not get what you want, unless the iron is divided into masses for the currents to get quickly upon it. Therefore they don't like these solid iron cores.

Prof. Rowland: I do not know that the theory bears upon the solidity of the core. Of course the more iron you get in there the better is the efficiency of the machine. And I suppose there would be no objection to dividing that cylinder up into a number of terms so that the Foucault currents could not exist when you put on the magnetizing force. I do not suppose there would be much objection to that if the exterior form was round; but I do have an objection to making it any other shape. Induced currents could be more thoroughly eliminated by dividing up the cross sections more perfectly than by making it even of a very elongated form.

Mr. Elihu Thomson: I do not agree that those induced currents can be abolished by dividing up the cores. They can be merely transferred to the wire circuits. The result will be to develop a powerful current in the wire circuit which will prolong the action beyond the time the solid iron cores would. There is another objection that is made to heavy iron cores. These external currents developed by these cores may set the machine into a constant state of vibration. That is, you have lamps which are adjusted into an arc circuit and the machine starts on a closed circuit with the carbons in contact. Before the electromotive force has come up to the proper point the field has become over saturated or over magnetized, and the result is that the arcs go beyond where they should go. As the machine goes on in its revolution the result is it cannot sustain that magnetization, because the field is not supported by the same current as at first; the extra current fades away slowly, the carbons go down and shorten the arcs, and a very sudden change of resistance takes place and the result is a constant trembling of the arc. That difficulty was met in the early development of the Brush machine; and it was overcome by putting a closed circuit of copper around the field.

At the same time I had worked at the same method of overcoming the fluctuation; it can be overcome in another way, that is by limiting the amount of iron. In an arc lighting machine we can get rid of this bad effect in most cases.

Prof. Rowland: I don't like to rise so often, but I think there is some misapprehension. I have not said anything about large masses of iron. I suppose you have to use the same masses of iron in my method as in any other. The only question is as to making them round or elongated. Of course, as Mr. Elihu Thomson has stated, by dividing this core up it becomes similar to a core of the Ruhmkorff coil, and the currents change very rapidly. From Mr. Silvanus Thompson's remarks, I thought that that was desirable, therefore I suggested it. One seems to think that it would be more desirable to have it take a long time, and the other a short time. I cannot accommodate both.

Prof. Elihu Thomson: This is simply making a jest of my remarks. You transfer the currents to the wire, and you support a field longer than it could be supported by the extra currents developed in the wire. Mr. Silvanus Thompson mentioned the fact that makers objected to this introduction of a mass of iron in which circuits could flow and retard the magnetization. I could say that by separating up such a core as that, you have probably introduced in compound machines at least these extra currents in the wires of the machine itself.

Prof. Rowland: If the time is short, then the force must be very great of course; you cannot help that. If the time is long the same current is spread over the long time, and there is less electric force. One cannot say that the current is transferred from the core to the outside. The same current might take place, and, if the resistances are the same, would take place, from the outside in both cases. By lengthening the time of action you decrease the electromotive force and decrease the external current. If the time is ten minutes you would have one electromotive force for the external current; if it is five minutes, the electromotive force would be somewhere near twice as great as before. The whole quantity of electricity which would be passing would be the same, however, in both cases.

Mr. Keith: In the machine which I have described, and which is a shunt wound machine, there is a constant difference of potential sustained at the terminals, whether there be one lamp in circuit or one hundred. The result is this: The magnetic field is constantly of the same strength; there is scarcely any perceptible variation. The speedy rise and fall of the strength of the magnetic field which is desirable in arc lighting does not prevail in incandescent lighting when the machine is so constituted as to be one of constant electromotive force. It is desirable in such machines to have a mass of metal which does not suffer speedy magnetic changes of any kind. This has been

arrived at as the result of experience, as well as from theoretical considerations. I have a machine running for electro-metallurgical purposes, producing a current of a thousand ampères with three volts of electromotive force. This machine has a large mass of iron in its magnet. The magnets are exceedingly long and made of a pattern which is well known. This machine takes from thirty to forty-five seconds to arrive at say ninety per cent. of its maximum working intensity of field. There is, after that, a gradual rise in this intensity extending over a period of five minutes or thereabouts. This is also a shunt wound machine. If we break the circuit to the field magnets, the current prevails in considerable strength, dying gradually away for about twenty-five seconds from the time of the breaking of the circuit. This construction is desirable for steadiness of current, where steadiness of current is desirable; but it is not desirable under conditions where we need to change the electromotive force, as in arc lighting.

Prof. Nipher: It occurs to me to say a few words in regard to an unfortunate machine which has been referred to several times, and which I saw the other day for the first time. It has two armatures and only two pole pieces. I was as much astonished as anybody could be when I saw it, but when I was informed that it weighed less than one thousand pounds and maintained a high strength of current, I thought it worth while to investigate what the machine would do before we said too much about how it worked.

The resolutions of the conference, with respect to the establishment of a National Bureau of Physical Standards, which were referred back to the committee having that matter in charge for further modification, were here read to the Conference, as follows, by the chairman of that committee, Prof. Newcomb:

Whereas, The recent rapid development of the applications of electricity requires the adoption and legalization of common standards of electrical measures, to form the basis of contracts for the supply of electricity; and whereas, the realization of such standards requires that all instruments for electrical measures be tested and verified by one central authority;

Therefore, be it Resolved, That this Conference deems it of national importance that Congress, in pursuance of its constitutional authority to fix a standard of weights and measures, should fix standards of electrical measures, and in order to secure the use of said standards should establish a Bureau charged with the duty of examining and verifying instruments for electrical and other physical measurements.

Resolved, That the President of this Conference be requested to communicate the above resolution to Congress through the proper official channels.

Resolved, That the U. S. Electrical Commission, conducting this Conference be requested to appoint a suitable committee to represent the Conference before Congress and to move for such legislation as will secure the object of these resolutions.

S. Newcomb,
Henry A. Rowland,
Charles K. Wead,
William A. Rogers.

After brief discussion, the resolutions were adopted. The Conference adjourned until Friday morning, Sept. 12.

Galvanometers at the Electrical Exhibition—II.

Deprez & Carpentier's Ammeters and Voltmeters.—These instruments are especially designed for industrial applications, and are approximately correct. They are strong and handy to use. Messrs. Jas. W. Queen & Co. exhibit

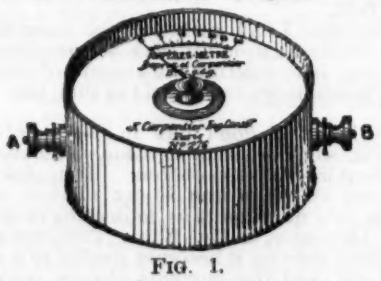


Fig. 1.

several of capacities varying from 10 to 200 ampères, and from 100 to 400 volts. Fig. 1 shows one of the ammeters, or *ampères metres*. The case is of brass, and is 120 millimeters in diameter and 60 millimeters high. The two binding-posts *A* and *B* on the sides serve to receive the conductors of the current to be measured. In the inside is a needle of soft iron in the interior of a bobbin formed of several turns of a copper ribbon insulated in the layers. The needle is mounted on an axis, and swings between the poles of a permanent magnet having a C-form. The two ends of the copper ribbon are connected, one to each of the binding-posts.

The ribbon is 10 millimeters wide, and differs in thickness in the different instruments to accord with the strength of currents they are intended to measure. The size of the ribbon is calculated for continuous use without excessive heating by the current.

The coil is placed obliquely between the two poles, instead of perpendicular thereto, as in other instruments of the kind.

The axis of the soft iron needle carries a pointer, shown on the face of the instrument, and it is so pivoted that the instrument may be used on a table, horizontally, or attached to a wall, vertically. By the deflection of the pointer over the scale the value of the intensity of the current is read at once in ampères, as the scale is empirically graduated to these values.

To avoid the otherwise necessary use of several instruments where currents of greatly varying magnitude are measured, attachments called "reductors" are provided to be affixed to the ammeter to vary the reading of the scale by division of the current. Fig. 2 shows one of the ammeters with a reductor attached.

Each reductor contains a resistance of which the resistance of the ammeter is a multiple. The current enters at *C* and there divides according to the law of derived circuits, so that a portion goes through *M* and *A* to the ammeter and out at *B* and through *n* to join that portion which passes through the coil of the reductor from *C* to *D*. The constant of the reading is then multiplied by $1 + n$ (*n* being the multiplier of the resistance in the reductor necessary to raise its value to that of the resistance in the ammeter) in order to obtain the value of the deflection.

The voltmeters have the same external appearance as the ammeters (see Fig. 3). The only difference is in the construction of the bobbin or coil. That consists of a very long and very fine insulated copper wire, having from 1,500 to 2,000 ohms resistance.

The manner of attaching the reductor to the instrument is, however, different, and there is also a difference in the places of attachment of the leading wires. Fig. 4 illus-

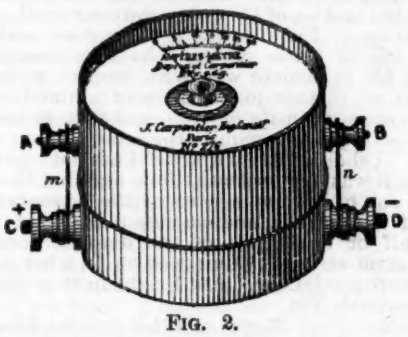


Fig. 2.

trates these points. Instead of the coils of the reductor being placed in multiple-arc with the instrument they are placed in series therewith, so that the total resistance is raised by the addition instead of lowered as in the case of the ammeter. The resistance of the coils of the reductor is a multiple of that of the voltmeter.

The current enters at *C* and passes through *p*, *A*, *B*, *q* and out at *D* (Fig. 4). The reading of the deflection of the needle is multiplied by the sum of $1 + x$ (*x* being the multiplier of the resistance of the voltmeter) used in determining the resistance of the attached reductor.

Storage Batteries and Incandescent Lamps.

Many interesting experiments and useful applications in electrical science can be made with storage batteries, a few cells of which will give a stronger current of electricity for a given time than double the number of galvanic cells. At the same time a few cells of primary battery can be used for charging the secondary or storage cells. The time required for charging depends, of course, on the strength of the charging current. Six cells of sulphate of copper battery, or three cells of carbon battery will do for charging. It is necessary to have a charging battery of a kind that will not polarize easily, so that it can be left on closed circuit with the storage cell for from twelve to twenty-four hours. In places where water or steam-power is at hand, a dynamo may be used to charge the storage cells. It has been found difficult to make small storage batteries that would absorb and retain the charge long enough to be of practical use, but after considerable experimenting, Mr. A. V. Meserole, of 22 New Church street, N, Y., can now furnish a durable and efficient storage battery from a size that can be carried in the pocket large enough to light a small scarf pin lamp, up to a size adapted to run an electric motor, or to light a lamp of several candle-power. These batteries can also be used for medical purposes (electro-cautery). A battery of from eight to twelve cells would work several small incandescent lamps, or a miniature arc lamp. The incandescent lamps mentioned are made from the size of a small acorn up to a size giving a

Fig. 3.

light of several candle-power. They are specially constructed to work with small battery-power. Galvanic batteries of special construction, also small dynamo machines and electric motors, are furnished by Mr. Meserole suitable for charging the storage cell, and for other purposes to which these articles could be applied.

Gaining Ground in Philadelphia.—Although gas is far more extensively used in this city for lighting than anything else, says the Philadelphia *North American*, it is not the only means of artificial illumination employed. Electricity is largely utilized, and every day its popularity increases. Chestnut street, from the Schuylkill to the Delaware, is now lighted in this way, and there are many business houses which at night are rendered brilliant by the radiance of the electric lamp. Nearly all the leading hotels in the city have turned it to account. So have the railroad companies in their stations and depots, and at many of the theatres and places of entertainment it is used outside as a means of attracting the attention of the public. It has also been introduced at the City Hall, Board and Market; at the Post-office and in many other buildings of a like character.

Police Telegraphs in New York.

It has long been desired to add to the electrical apparatus at the service of the police in this city. The New York *Times* publishes the following on the subject:

It is probable that the police of the Fifteenth Precinct will soon be under electric surveillance, and that a system which was believed to have proved impracticable will be tested, free of expense to the city. Months ago boxes and lines were put up in the streets of the Fifteenth Precinct, and an indicator board, switches and batteries in the Mercer street station house. But trouble came when it was attempted to put the electrical idea into mechanical shape. Last spring the indicator board was taken out of the station house, and it was said that the scheme was impracticable. Within a few days the indicator board has been put up in the station house again, and those interested in the system announced that an expert electrician had mastered all difficulties, and that in a week or ten days a public test of the lines would be given.

The system aims at doing all that the Chicago system does, and avoids what has been criticised as its objectionable features. In the Chicago system many signal boxes are connected on one circuit, so that a break, cross, or other interference at any point renders the whole system useless until the check is removed. Such a system compels the overhauling of the whole circuit until the fault is found. Then, again, in Chicago the signals are tape-recorded, making necessary deciphering and searching of records to interpret signals. Telephonic systems have hitherto proved useless. The system in the Fifteenth Precinct comprehends a separate wire connection for each of 32 posts or patrols. There is a signal box at each end of each post, and in the station house, on the indicator board, are 64 indicators—one for each end of each post. Registration of correct duty by the officer on post and the timing of the patrolmen are automatic, and the operations of the indicators are clear. They include calls for assistance and ambulances, so that, if the system is carried out as planned, an officer will seldom have to leave his post. Each box for police signals has a separate key, so that meddling with them by practical jokers or criminals is not easy. The "ambulance" and "assistance" sections of the boxes have common keys. Later on a patrol wagon and an ambulance may be kept in readiness at the station house. At present the police commissioners have no fund out of which they could pay for the system, and, should they approve of it, they would have to ask for a special appropriation. The cost of the experimental lines, etc., is large, but those interested in the scheme do not tell what it is.

The Wired Words of a World.

The telegraph appears to have made more progress in this country than in any other country. The number of American telegraph offices in 1882 was 12,917, and the number of telegrams forwarded during the year was 40,581,177. The number of telegraph offices in Great Britain

Fig. 4.

and Ireland in 1882 was 5,747, the number of telegrams forwarded being 32,965,039. Germany had 10,803 offices, the number of telegrams forwarded being 18,362,173. France had 6,319 offices, the number of telegrams forwarded being 26,260,124. Russia had 2,819 offices, the number of telegrams forwarded being 9,800,201. Belgium had 835 offices, the number of telegrams forwarded being 4,066,843. Spain had 647 offices, the number of telegrams forwarded being 2,830,186. British India had 1,025 offices, the number of telegrams forwarded being 2,032,903. Switzerland had 1,160 offices, Italy 2,590 and Austria 2,696. The number of telegrams forwarded in these three last-mentioned countries was 3,0461,82; 7,026,287 and 6,626,203 respectively.

Lowell Police Telegraphs.—The Lowell District Telegraph company will have completed for use in about three weeks a police telegraph system, which they have been ordered to construct by the committee on police. There are to be 111 boxes, operated by a crank, like those of the present district system, and located on the circuit of each officer's beat. They are to be covered like the fire-alarm boxes, and poles have been erected upon which to place them in some localities. The officers sent out on the night and day patrols, will report to the police station when they are at different boxes on their beats, and their message will be received automatically by the indicator at the station. When assistance is wanted, the fact will be sent in a similar manner and inscribed on the indicator. A police team, with officers, will then be sent to the point at which assistance is desired. A great advantage of the new system will be that officers on the outside beats will not need to leave them to convey prisoners to the police station, thus leaving the beat unprotected for a long space of time.

A Practical Underground System.

Few electrical questions have occupied more attention during the last five years, and few will more disturb the public mind in the next decade, than the practicability of running wires underground. It is true that the subject has been discussed *ad nauseam*, but the end is not yet. While legislatures and civic authorities are passing laws and ordinances against aerial wires, many of the electrical companies say, as they quietly fold their hands, that they have not yet found a good, feasible, cheap, working underground system, and that until some such system is found they will do nothing. This state of things cannot continue for ever, and in the belief that the rapid multiplication of electrical wires, for uses new and old, must

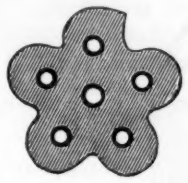


FIG. 1.

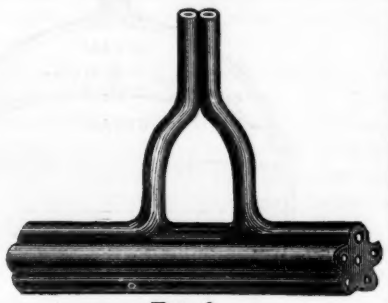


FIG. 2.

before long bring matters to a crisis, the thoughts of the inventor and capitalist are seriously concerned with underground schemes.

We have never concealed our opinion that the difficulties of underground electrical transmission have been popularly under-estimated, especially by those who have been most eager to banish aerial wires, and we have also been free in expressing our opinion that some of the schemes proposed are foolish, useless and fraudulent. When a system comes under notice, however, with favorable reports after the most severe tests, it is but right and proper that the said system should receive its due of approval. We have been interested in the display at the Electrical Exhibition, of the Standard Underground Cable Company, of Pittsburgh, Pa, and we illustrate on this page some of the productions of the Company, who operate under the patents obtained by Mr. R. S. Waring. His inventions, the result of much experimentation, possess various and novel features, and appear to minimize and neutralize induction and its effects to a remarkable degree. The Waring cables are made with an outer insulation or shield of lead, which is not only an extremely durable metal, but protects the conductor from induction and allows the cable, of which it is a component part, to be bent to any acuteness of angle, and to be laid almost everywhere. The cables of the Standard Company have a heavy lead casing, with differing numbers of conductors, and of any gauge of wire from No. 4 to No. 26. Fifteen hundred feet of cable wires for street service can be packed in a box not more than a foot square.

Fig. 1 is a sectional view of the Waring telegraph cables used with so much success in Washington. One of the ridges differs slightly from the others, its sharp corner denoting the number of that particular conductor, from which as a start any of the others can readily be found. A great advantage claimed for the Waring cable is the ease with which any new service can be looped into the main cable, without cutting the cable as a whole and without disturbing the other conductors. Herein is apparent the use of the marked ridge of the cable, and Fig. 2 is a sample of the manner in which a wire can be looped out for a way-office. For connections of this kind a two wire cable is used. Fig. 3 shows a section of electric light cable, in

FIG. 3.

FIG. 4.

which Nos. 4 and 6 gauge stranded conductors are used. These are for arc lighting, but smaller cables can be had for incandescent circuits. It is believed that the latter will enable a greatly extended use of the incandescent light in mines and on shipboard. The insulating material of the cables will not carbonize, it is said, at less than 1800 degrees of heat; it may be melted by a heavy charge of lightning, but will resume its former normal condition without having sustained injury. The insulation is upwards of 200 megohms per mile, it is claimed, and has not fallen off in any instance; while a remarkably low specific inductive capacity is claimed for it. The company say that the static effect is not a source of annoyance in the least, but that all the experiments made with the different systems of printing telegraph and the quadruplex have been entirely satisfactory. Fig. 4 shows the 5-wire telephone cable, and Fig. 5 the 6-wire telephone cable. Other kinds are made, including a handy single lead-covered wire for burglar alarms, bells, clocks, hotel annunciators, and suitable to be laid in the walls of a building so as to be completely out of sight. Another style is the flat or ribbon cable, which can be laid on woodwork, and looks like a neat extra molding. A third special variety is the heavily armored cable for submarine use.

The Waring cable is made in continuous length, in the process of manufacture, and is then cut up to any size adapted to circumstances and general convenient handling. Thus, for instance, the 6-wire cable for Washington was shipped in half mile lengths. The method of jointing or splicing is illustrated by Fig. 6. The cable ends are first stripped of the lead for about an inch and a half, and then the wires bared of the insulation are joined in a double twist and soldered. This joint is then re-covered with the insulation, wrapped with silk, and served with strips of sheet lead, which preserve the metallic continuity of the division between the wires. A sleeve of lead pipe, slipped previously on one of the ends, is then brought up over the joint and dressed in close to the cable at both ends, and a solder joint wiped at each end of the sleeve—all as indicated. The sleeve is then tapped, and the melted insulation is run into the pipe so as to fill it up to the exclusion of all air and moisture. The tap is then closed and the joint is laid down. It is said that the operation of making a joint does not occupy more than an hour.

In Fig. 7 is shown the system adopted for laying the cable. The practice has been to dig the trench about two feet deep, at a distance of two or three feet from the curb, and then to drive the reel, which is mounted after the manner of a hose carriage. As the reel moves along, the cable is paid out, and the trench is refilled at the same rate

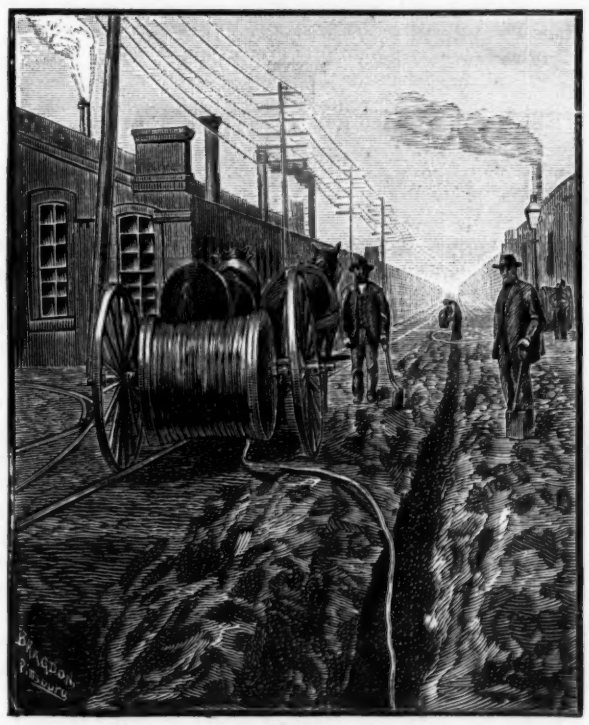


FIG. 7.

of progression. Over a thousand feet a day have been easily laid in this way.

Reference was made at the outset of this article to the successful tests had with the Waring cables. The most conspicuous experiment is that at Washington, where the Standard Company laid a large quantity of cable last year for the use of the National Government, connecting telegraphically and telephonically the Capitol, the Executive Mansion and the State, War and Navy and other Departments. During the winter, when heavy storms interrupted communication by aerial lines, this underground service proved to be of the greatest efficiency and utility, and worked without fault. The report to Congress of the Secretary of War on the Waring system is highly commendatory of it, the officials who used the wires being thoroughly satisfied. A line of cables was also laid in Washington for the District authorities, to take the place of one of the air trunk lines for fire alarm and police telephone work. In the Spring of 1882, a 5-wire cable was laid between the Vesta Oil Works, on the Allegheny River, and the Chamber of Commerce building, Pittsburgh, the two places being about nine miles apart. Over this cable telephonic communication is entirely successful, although the cable lies in the earth without any protection. Other cables are working equally well elsewhere. We quote below the report of Prof. George F. Barker, of the University of Pennsylvania, on the Washington wires, made to Col. Rockwell, the Superintendent of Public Grounds and Buildings, and dated April 21, 1884: "While in Washington last week I examined somewhat carefully the underground cables now working in the streets of that city, made under patents held by R. S. Waring, of Pittsburgh. In my judgment, the theory of this cable is scientifically sound. Its anti-induction feature consists in the use of metallic screens between the wires—a device the effectiveness of which was first pointed out by Professor Henry. Protection from leak is secured by excellent insulation. In practice the cable seems to answer all requirements. Conversation was readily carried on over circuits 2.6 and 4 miles respectively, and this with various forms of telephone. A remarkable freedom from extraneous noises was observed, the articulation, in consequence, being sharp and clear. I made a test of the insulation-resistance of this cable, using for this purpose the section which extends from Seventeenth street and Pennsylvania avenue to the Capitol, a length of 2.6 miles by the route taken. The instruments employed in the measurement were those in use in the office, and the results, therefore, can be considered only approximate. It appears from this test that

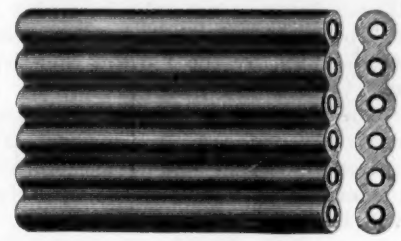


FIG. 5.

the cable-insulation had a resistance of between two and three hundred megohms per mile. Abundant evidence is at hand that the working of the telegraph lines through the cable is in every way satisfactory. Tapping of wires being impossible, secrecy is assured. The retardation predicted of underground cables has not in any case been noticed."

A system of this kind has peculiar adaptability to railway service, and the company are likely to find abundant occupation in supplying their cables to be buried along the tracks.

A Granger's Experience with the Telephone.

A careful census would probably reveal the fact that a great many million people in this country have never yet used the telephone and know nothing of its mechanism. The Sacramento *Record-Union* tells the following laughable story of the manner in which a raw Californian granger tried lately to operate a transmitter:

Yesterday, while Mr. Smith, the secretary of the State Agricultural Society, was very busy he was approached by a granger who desired to telephone to a down-town store. "There's the telephone; go and help yourself," said the secretary. The granger approached the instrument rather timidly, eyed it cautiously for a few moments and then, taking a piece of paper, wrote a message. He then rolled up the paper and tried to push it in the aperture in the transmitter. Failing in his attempt with his finger, he took his lead pencil and jammed it in, destroying the vibrating plate. With an air of satisfaction he took his seat and awaited a reply. After about ten minutes he became discouraged, and thinking he perhaps had not sent the message on the right line, he wrote another and jammed it into the hand telephone, and, to make sure work, rammed it home as he would a ball in a rifle. He again sat down, and after waiting nearly half an hour became discouraged at getting no reply, and thanking the secretary for the use of the telephone, walked out, remarking that he would not give a continental for the machine, anyhow. Soon afterward the secretary, wanting to use the telephone, was astonished at its appearance. It was stuffed full of manuscript and ruined. The instrument was taken apart and the messages taken out; all read as follows: "Bakker and Hammeltonn—Send me to the Pavillion a six inch long munkey rench. Yurs Trully J. E." The machine was repaired at a cost of $15, which the verdant

FIG. 6.

granger paid. To avoid similar occurrences the telephone has been fenced in and a sign placed over it with the words printed thereon: "Beware of the dog."

WASHINGTON, D. C., DISTRICT SERVICE.—Mr. D. H. Bates and Mr. Robert Garrett have recently been elected directors of the Mutual District Messenger Co., of Washington, D. C. That company, under the supervision of Mr. Wm. F. Chester, is doing exceedingly well, and is astonishing the business men of the city, who at first thought that it would not prove a success.

A MERITED PROMOTION.—Mr. John Riley, late with the Mutual District Messenger Co., Limited, but more recently with the American District Telegraph Co., "on trouble," has been promoted to the important position of inspector of First Division of the A. D. T. Co. Always diligent, polite and faithful, he has earned this promotion, and Superintendent Frost is to be congratulated upon securing so desirable an aid.

A. D. T. CO.—An important change has been made in the Messenger Department of the American District Telegraph Co. of this city, by the appointment of W. F. Sanford to the position of manager. The A. D. T. service requires over 1,200 messengers, and Mr. Sanford while with the Mutual District Messenger Co., Limited, developed peculiar abilities for the proper handling of messengers.

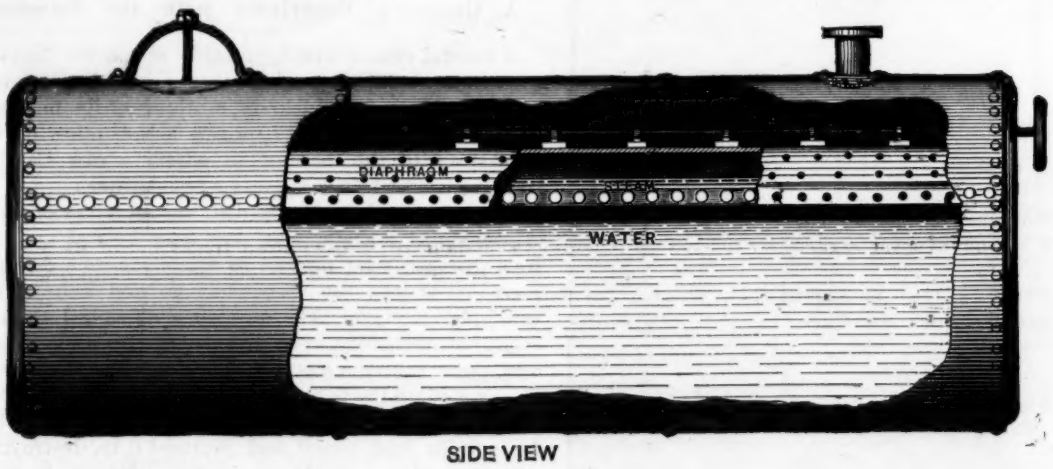
A Preventive of Boiler Explosions.

The fact that nearly every electric lighting plant depends for its prime power upon the steam engine, and that in almost every instance in which dynamo-electric machines are used for purposes other than lighting, the same motive agency is resorted to, renders the interest of the electrical engineer in the theory and practice of steam engines a remarkably lively one. We have recognized the importance of the subject in our series of articles on steam engines. In the present article we go a little further, and offer another view of the matter for consideration in calling attention to an invention now occupying the thoughts of many advanced machinists, boiler makers and engine builders. Several years have passed since Mr. D. T. Lawson made his first experiments on boiler explosions, near Pittsburgh, Pa., but that gentleman has now not only deduced a theory from his results, but carried the theory out concretely in the boiler manufactured by the Lawson Non-Explosive Boiler Company, 155 Broadway, New York. We cannot do better, in elucidation of Mr. Lawson's methods, than state his theory briefly, and give a few illustrations of the boiler itself. Even our readers who are not ordinarily occupied with the mechanical questions relating to electrical applications will find the subject suggestive.

The Lawsonian position, stated by Mr. Thomas Kays, is as follows:

The only explosive material about a steam-boiler is water; and water when superheated, which can be done only under pressure, will explode upon a sudden removal of that pressure, with a force quite equal to that of dynamite.

The boiling point of water varies with pressure. In a vacuum water boils at 70° sensible heat. Under atmospheric pressure it boils at 212°, and cannot be made hotter unless confined under additional pressure, because the escaping steam carries off the heat as fast as fire can impart it. In a steam-boiler under 10 lbs. pressure it boils at 241°; 50 lbs., 300°; 100 lbs., 340°; 200 lbs, 389°.



SIDE VIEW

Fig. 1.

Water when heated to the boiling point requires 966° additional heat to change it from the state of water to the state of steam. This change is substantially instantaneous at all pressures. As each molecule of water absorbs the last of the 966° it instantly explodes into steam. As the last degree is absorbed, cohesion is overcome and repulsion becomes the predominant power.

The change of steam to water is also instantaneous. Steam remains in its new state only so long as it retains the 966° of latent heat, and the moment it, at full volume, with only 212° of sensible heat, parts with one of these degrees of latent heat it returns to water.

The explosion of water is similar to that of gunpowder in some respects, but different in others. Each grain of gunpowder passing from the solid to the gaseous state explodes when it has absorbed a certain degree of heat. So with water. Each molecule of water, at the instant it has absorbed 966° of heat above the boiling-point, explodes and passes from water into steam. The expansive quality of the two is different, powder increasing in bulk 800 times, while water increases 1,720 times. The mode of exploding and the general result, large and sudden increase of bulk, are similar. In other respects they differ widely; the explosion of powder is by chemical action; the explosion of water is a physical change only.

Water differs widely from powder and all other explosives in another remarkable particular. Only a portion of the water may explode—one molecule, the half, or the whole mass. These various amounts in exploding produce results ranging from violent explosions to mild ruptures and the safe operation of the boiler.

When a grain of powder starts to go from the solid to the gaseous state no power can stop it. It may be confined, but combustion, once begun, goes on to completion. So with a molecule of water. It may be put under such pressure that it will not fully expand, but, once begun, it changes its state from water to steam.

The true source of the development of the great destructive power in a steam-boiler is the sudden *concentration* of the sensible heat in the water above 212° (or above 70° in case of a vacuum caused by the condensation of steam) into a part of the molecules of water, passing into them the 966° necessary to change them from the state of water to the state of steam.

That the stored heat in a boiler concentrates to form steam is shown by familiar experiments:

As, for instance, causing water at less than 212° to boil by placing it in a vacuum; or by merely condensing the steam over heated water in a bottle.

Again, take a steam boiler under a pressure of 100 pounds and a corresponding temperature of 340°. Remove the fire and the formation of steam will cease. After a short time raise the safety-valve, and the water will begin to boil, and generate and give off steam continuously as the pressure is reduced, until a temperature of 212° is reached, and enough steam will be thus generated and blown off to fill the boiler very many times.

These tests show that the boiling-point of water is lowered by simply diminishing the pressure. They show this, and also show the true theory of boiler explosions. They prove in the most conclusive manner that the sensible heat above 70° stored in the water concentrates in a part of the molecules of water, giving to them the 966° necessary to change them into steam. The water ceases to boil, no heat is applied, and by merely reducing the pressure the water again boils. The 966° above the boiling-point necessary to cause ebullition are not absorbed from the fire at the instant the water begins to boil the second time. They are already stored up in the water.

Take a boiler containing 10,000 lbs. of water at a pressure of 200 lbs. and a corresponding temperature of 389°. Suddenly reduce the pressure to 50 lbs. per square inch, under which pressure water explodes at 300°. There are stored in each of the 10,000 lbs. of water 89° of sensible heat above the exploding point—in the aggregate 890,000 thermal units, enough to convert 921 lbs. of this superheated water into steam. In an instant these 89° of sensible heat in each pound of water are absorbed by the molecules of water at the surface and for a considerable depth, and suddenly these 921 lbs. of superheated water explode into steam.

Thus it will be seen there is sufficient destructive power stored in the boiler when thus put in action to cause an explosion. If the reduction of pressure caused by the withdrawal of steam be moderate, and such draught be continuous and uniform, there will be no danger; but if the draught is considerable in quantity and instantly checked, the nascent steam thus suddenly formed and thus suddenly checked will give an *impact* or *striking blow* upon the shell of the boiler, the aggregate force of which is equal to the weight of the water before it passed into nascent steam multiplied by the square of the velocity with which it strikes.

The instantaneous check to the exploding water acts upon the boiler with the same effect as that produced by quickly closing the valve of a water main. In the one case it is the weight of the falling water, and in the other it is the force of exploding water, but the striking effect of the blows is the same and is measured by the same rule.

From the above considerations Mr. Lawson arrives at this conclusion as to the cause of explosions:

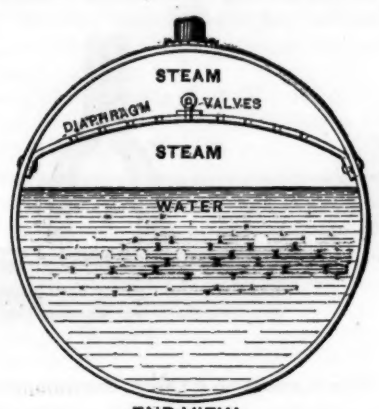
The water in the boiler, under pressure, is superheated and possesses a highly expansive power. Upon a sudden removal of the pressure, without a corresponding reduction of the temperature, it starts into violent evaporation. This mass of nascent steam is checked by coming in contact with the solid and unyielding shell of the boiler. The result is that the aggregate force of this nascent steam strikes every square inch of the shell of the boiler at the same instant and with the same force, and with a power far in excess of the tensile strength of the boiler; and, moreover, this force is augmented at the instant the shell gives way by an immense reserve power caused by the further evaporation of the water in the boiler.

This theory is in unison with natural laws, and upon it every explosion, bursting, or rupture of steam boilers can be fully explained, and cannot be upon any other.

Mr. Lawson has therefore expressed the theory and the results of his experiments in 1881 and 1882 in the construction of a boiler with a partition plate or diaphragm dividing it into two compartments, the lower containing the water and the upper containing steam only. The steam passes from the lower to the upper compartment through numerous small perforations and a number of small valves in the diaphragm. The aggregate openings of the valves and perforations should be less than the valve through which the engine is supplied. By this means the pressure upon the surface of the superheated water is kept approximately uniform, and all sudden explosions of any dangerous quantity of water into steam and consequent striking blows are avoided.

The diaphragm extends the length and width of the boiler, and is firmly riveted to the sides and ends thereof, as shown by Figs. 1 and 2. It may be circular or flat and so located as to cut off about two-thirds of the usual steam space.

The perforations and valves vary with boilers of different size. The aggregate area of all the perforations and valve orifices should be about ten per cent. less than the area of the steam-port. In ordinary sized boilers there



END VIEW

Fig. 2.

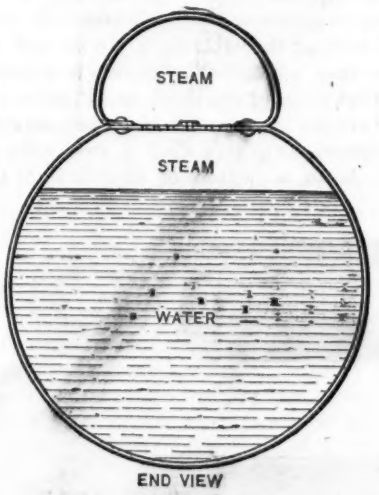
should be one perforation of one-quarter of an inch in diameter to each horse-power, rating ten square feet of heating surface to the horse-power, and such number of valve orifices of about two inches in diameter as to make up the balance of the aggregate area.

This lessening of the aggregate area ten per cent. below that of the steam-port will give a very slight diminution of pressure in the engine with steam working at full stroke, but will give practically full pressure at every other point of cut-off.

There must be two steam gauges used, one connected with the water space below, and one with the steam space above the diaphragm.

When the boiler is set and ready for use such small valves should be closed. As the steam is generated and the engine put in operation at its full capacity, any additional steam required is obtained by gradually and partially opening such valves until the required amount is liberated and ascertained, when such valves are set, and need but little further attention. In thus arranging such valves particular attention should be paid to the steam gauges. The valves should be opened only to that extent at which the pressure upon the superheated water in the lower compartment, as shown by the gauges, remains approximately uniform with that in the upper, with the engine in full operation. Thus arranged, any unusual and sudden withdrawal of steam from the upper chamber is attended with no possible danger.

Boilers thus constructed and arranged are protected against explosions, whether the water wholly or partially fills the water compartment. If wholly filled, a sudden



END VIEW

Fig. 3.

reduction of pressure in the steam compartment can instantly affect only the surface of the water to the extent of the aggregate area of the perforations and valve orifices, and no dangerous quantity of water can be thus exploded. As the pressure upon the water below the diaphragm is thus slightly reduced, small portions of the water pass into steam and maintain uniformity of pressure.

If the water should get low, thus accumulating an unusual quantity of steam below the diaphragm, there can be no danger of an explosion. The discharge of steam from the ordinary boiler into the empty pipes and cylinder upon the sudden opening of the valves, is at a velocity of over 100,000 feet per minute, and for an instant there is a great reduction of pressure upon the surface of the superheated water. This cannot occur with the Lawson diaphragm in a boiler. With it the passage of steam

from the water compartment below the diaphragm to the steam space above it is limited to that quantity used by the engine with the piston moving at the rate of say 600 feet per minute, and cannot exceed this precise amount to any great extent, although the steam may, from some unusual cause, be temporarily rushing from the steam space above the diaphragm fifty times as fast. The diaphragm limits the quantity of steam discharged from the water compartment to the exact amount necessary to drive the engine in full operation, and the liberation of this amount at such uniform rate can be attended with no possible danger.

The Lawson diaphragm is to the steam boiler what the air-chamber is to the hydraulic ram. It performs a similar but much more important function. The elasticity of the air moderates the otherwise solid blows of water upon the pipes; the diaphragm preserves uniformity of pressure upon the water, and thus prevents its explosion and the consequent violent and irresistible concussive blows upon the shell of the boiler.

Explosions are thus prevented, not by extra strong boilers, but by preventing the occurrence of the cause. Boilers thus constructed can be safely operated at a pressure closely approaching their actual tensile strength.

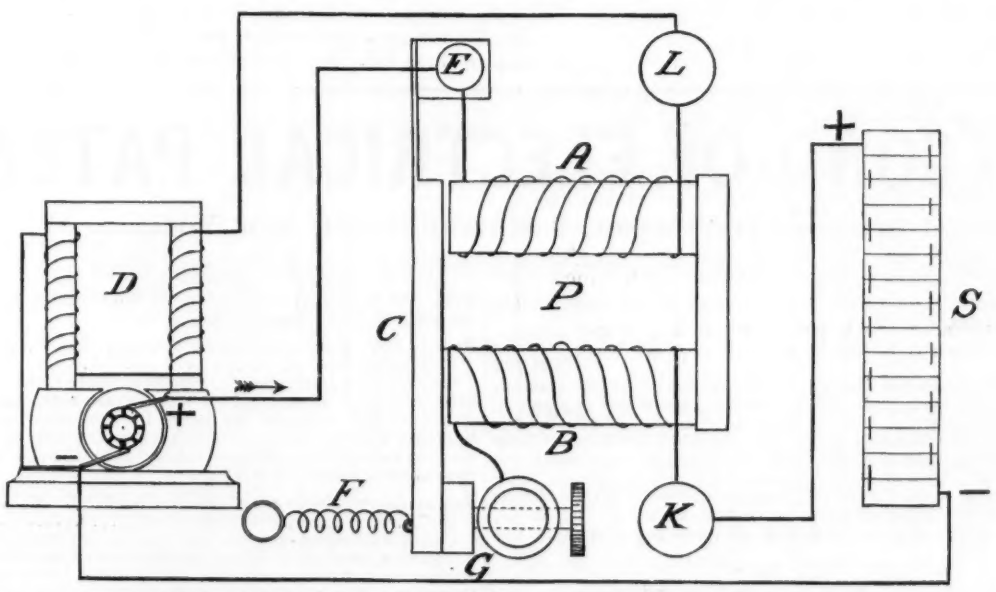
The invention is applicable to every style of boiler, and can be readily applied, internally or externally, to new or old boilers.

Figs. 1 to 3 fully illustrate the invention.

A New Automatic Dynamo Protector.

The want of a simple and reliable instrument to prevent the changing of polarity, and even the disablement of dynamos, when employed in charging storage batteries, has long been felt.

Dating from the time when the Faure storage batteries were put upon the market, several attempts have been made to produce the required instrument. Mr. A. G. Holcombe, of this city, claims to have designed and constructed the first really efficient apparatus in January, 1883. This had the merit of breaking the circuit in case of reversed currents, thereby protecting the dynamo, but it lacked any provision for automatically closing the circuit. The simple instrument which we illustrate, also by the same inventor, is reported most efficient and reliable in its action. Its construction will be clearly understood by reference to the diagram. The system referred to in the illustration consists in the shunt wound dynamo *D*, the protector *P* and storage batteries *S*. The protector consists of a horseshoe electro-magnet with the coils formed of two spools *A* and *B* wound independently of each other, an armature *C* attached to the binding post *E* by a strip of spring brass or other suitable material, and kept from contact, when no current is passing, by an adjustable spring *F*. *G* is a binding post with a platinized contact piece to carry off the current when the armature is drawn up to the poles of *A B*. *K* is a binding post connecting with the coil *B* and

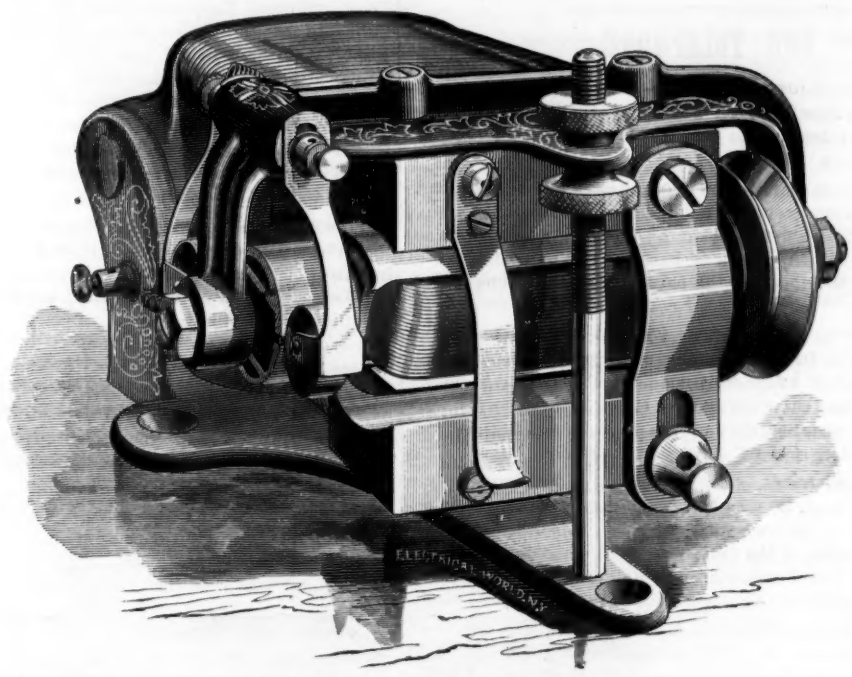


THE HOLCOMBE AUTOMATIC DYNAMO PROTECTOR.

the storage battery *S*. Starting from the + brush of the dynamo the current passes along the main line in the direction of the arrow to the binding post *E*, thence through the spool *A* to the binding post *L* and back to the field of the dynamo through the field to the — brush. When the magnet *A* becomes charged with sufficient strength to attract the armature and make contact at *G* the main current will flow through the armature *C* through *G*, thence through the spool *B* to the binding post *K*, thence to the + pole of the battery and through the battery to the — brush of the dynamo. As long as the dynamo produces enough electromotive force to overcome the resistance of the battery, the circuit will remain closed, but as soon as the reverse current is set up from the batteries to the dynamo, either from stoppage of the dynamo or other causes, the polarity of spool *B* is reversed. The armature *C* is released. The spring *F* acting on the armature holds it off until the dynamo has attained sufficient electromotive force to energize the spool *A*, attract the armature *C* and again close the circuit. In cases where power is of a variable description, such as, for instance, that of a wind motor, this protector will be found particularly valuable, as it will enable the most variable power to be applied to drive dynamos for the purpose of storing electricity without constant attention. The same applies to factories and mills where waste power may often be utilized, and generally under all circumstances, no dynamo used for storing electricity, says Mr, Holcombe, should be without one of these protectors, seeing that it is an absolute safeguard in the case of breakage of belts, sudden stoppages, or slowing down of the motive power. One of these instruments can be seen at the room of the Equitable Electric Co., 41 Centre street, New York.

Diehl's Electric Motor.

At the Singer Manufacturing Co.'s exhibit in the International Electrical Exhibition may be seen several sewing machines run by various electric motors invented by Mr. Philip Diehl, the inventor engaged by the sewing machine company.



DIEHL'S ELECTRIC MOTOR.

One form of motor is made part of the flywheel of the sewing machine, but the one most in use we illustrate by the accompanying excellent engraving which shows the motor at about two-thirds size.

The base carries the upper core and pole of the field magnet attached permanently to it. The under core and pole is hinged at the rear of the motor just above the binding post there shown. It is so hinged for the purpose of changing the speed of the motor to suit requirements by moving the under pole to or from the armature by means of a connecting rod and treadle not shown.

When the pole is moved away from the armature its attractive influence is not so strong, and therefore the power and speed are decreased. If the pole be swung downward until its lowest limit is reached, electric circuit is broken entirely at the point where the button on the under pole and the spring projecting from the upper pole meet. The post with the two jam nuts on it is for the purpose of fixing the position of the upper pole.

The armature core axis and pulley are cast as one piece of iron, and armature as made is of the Siemens H-type. One pole of the armature core is extended and bent so that the axis at the commutator end is in its proper place, and there is a space between this extension and the other pole. At the other end of the other pole a like extension for the pulley axis is provided. So there are longitudinal and transverse spaces lengthwise around the core to receive the coil; and yet the poles are not connected by iron except within the coil.

The commutator is of the kind usually attached to bi-polar armatures—that is to say, it has two sections.

Mr. Diehl shows one of these motors very much improved. He mounts the field-magnet so that both the poles are swung to or from the armature simultaneously, and to a considerable greater distance than in the motor we illustrate. This improvement enables the stopping and starting of the motor, without breaking circuit through it, simply by a movement of a treadle to move the poles from or to the armature. The object of this is here explained: Several of the motors are placed in multiple arc in place of one arc-lamp of a series. Of course, in such case, if the circuit be broken to one motor, it is necessary for satisfactory working of the other motors that a like resistance be substituted for the motor resistance. These resistances are expensive, and the spark on the switch at changes soon damages the switch to the extent of needing repairs. By the use of the new motor, switches and resistance coils are unnecessary.

The motor possesses the commercial qualities of cheapness of construction and adaptation to the requirements of the user.

Deoxidized Copper Wire.

The subjoined appeared in the Houghton, Mich., *Mining Gazette* of Oct. 2:

The rapid development of the telephone and telegraph business throughout the civilized world is a matter of material interest to the copper miners of Lake Superior for the reason that the metal they produce is of a grade that is ahead of all others for use especially on telephone lines.

A drawback to the more general employment of copper wire is the fact that the manufacturers, so far, have been unable to make a quality of wire that is not open to the charge of "sagging," and other minor difficulties, caused by the peculiar nature of the metal in its regularly refined state.

We are informed that the obstacle in the way of providing a copper bar that can be drawn into perfect wire for telephone and telegraph purposes no longer exists, owing to the discovery made by Mr. James R. Cooper, superintendent of the Detroit and Lake Superior smelting works, of a process or system by which he eliminates practically all the oxygen from Lake Superior copper, thus furnishing a metal that will supply the demand in the way of a serviceable first-class telephone and telegraph wire.

If Mr. Cooper's so-called deoxidized copper is all that is claimed for it, there is no reason why the future demand for telephone and other uses, provided the value of the improved metal is brought to the attention of those interested, should not consume annually a considerable amount of Lake Superior copper.

They Love the Work.

"Why is it that the employés of telephone offices are all ladies?" Mrs. Brown made this inquiry of her husband.

"Well," answered Mr. Brown, "the managers of the telephone companies were aware that no class of employés work so faithfully as those who were in love with their labor, and they knew that ladies would be fond of the work in telephone offices."

"What is the work in a telephone office?" Mrs. Brown further inquired.

"Talking," answered Mr. Brown, and the conversation came to an end.—*Somerville Journal.*

THE New Haven (Conn.) Electric Light Co. will increase its plant.

THE TELEGRAPH.

Striking for Back Pay.—The operators on the government telegraph lines in Mexico struck on Sept. 28 for three months' back pay. Some were induced to resume.

Lower Rates Again.—The Baltimore & Ohio Telegraph Company has reduced the rate interchangeably between all offices in New England and New York City to 25 cents for 20 words, and one cent for each additional word. Of course the Mutual Union has again cut under.

A Slight Mistake.—A California editor recently attempted to telegraph to friends in a neighboring town: "Cannot be down till Thursday—foreman drunk." He went down on Thursday, and was astonished by the hilarious manner in which his friends received him. It came out that the telegram, when received, read: "Cannot come down till Thursday forenoon—drunk."

Pneumatic Tubes.—The pneumatic tube system of the W. U. Tel. Co., between 195 Broadway and 23d street, was tested on the 6th inst., the first message being sent by G. V. B. Frost, Supt. Am. Dist. Tel. Co. The answer was received in remarkably short time. The completion of this system will revolutionize the messenger service in this city.

THE TELEPHONE.

West Coast of South America.—A certificate of incorporation was filed in New York on the 2d by the West Coast Telephone Company, intending to operate, it is said, lines between Chili and New York.

Closing an Exchange.—The unusual spectacle has been witnessed of a telephone exchange being closed. The Bell Company, Silver City, N. M., wound up their business on Sept. 15, on account of the general stagnation of business. The outfit goes to Albuquerque, N. M., doubling the capacity of the exchange already there.

An Underground Cable.—The Philadelphia Electrical Department has begun the laying of an underground cable in the West Park to effect telephonic connection between Belmont pumping station and the reservoir at George's Hill. The purpose is to test the practicability of the cable manufactured by the Standard Underground Company of Pittsburgh.

Output of Telephones.—The net output of instruments for the month ended Sept. 20 was 1,374, against 616 the previous month and 4,365 in the corresponding month of 1883. The net gain for seven months of the fiscal year is 21,594, compared with 39,657 in 1883. The income of the Bell Company continues very large, regardless of the slight gain of instruments in use.

Threatening to Cut Wires.—A. H. Mershon, the owner of 160 feet of roofing at No. 1338 Chestnut street, Philadelphia, has given notice to the Western Union, Bell Telephone and other companies maintaining a telegraphic way over his property, that if the wires are not removed he will cut them down. Through damage done to his building by linemen traversing the roof, Mr. Mershon says the wires have cost him over $1,000 for repairs.

THE ELECTRIC LIGHT.

Portland, N. S.—The Brush Co. have sold a large plant to the important city of Portland, Nova Scotia, to be used in lighting that place.

Silver City, N. M.—The Electric Light Co., at Silver City, N. M., have received the contract to light the business portion of the town with seven lights on twenty-eight feet poles, the authorities paying $1,800 per annum for the service.

Mobile, Ala.—It is proposed to use the Thomson-Houston light extensively in Mobile, Ala., and also to use Star iron towers. About seven towers would be required, 125 feet high each, with five arc lights of 2,000 candle-power each, to illuminate the streets.

Activity of the Armington-Sims Co.—The Armington & Sims Engine Company, Providence, R. I., is running full time, and all the men it can work. It is building three 16½x24-inch engines, 150-horse power each, for the new station of the Brush Electric Light Company, of Boston. It is also building two engines 12½x10, for the electric light plant of the steamer Providence, of the Fall River Line, while a number of other orders from electric lighting companies are now in hand.

Lighting Washington Gratis.—A committee consisting of S. Norment, M. G. Emery, J. L. Barbour, R. Boyd, S. W. Tullock and W. Dickson, of the U. S. Electric Light Co., Washington, D. C., have offered the Columbia District commissioners to light Pennsylvania avenue, from the Capitol to the Treasury, with twenty or more arc lamps, until July 1, 1885, free of cost to the city. At present the company are furnishing on that avenue to private parties more than twice the amount of light derived there from gas.

In New York Churches.—During the absence of the Rev. Dr. Taylor in Europe, the trustees of the well-known Broadway Congregational Tabernacle have introduced the incandescent light into that building with excellent results. Prof. George P. Fisher, the distinguished Yale theologian, who always pays particular attention to the ventilation of the room in which he delivers his lectures to students, says that the torpor of preachers and drowsiness of congregations are often the result of a lack of proper ventilation, and his wise suggestion should have the attention of church trustees who are considering the advantages of electric light.

Objecting to Towers.—And now come vessel captains, says the Detroit *Free Press*, with their objection to the electric light in Detroit. A reporter hearing a number of old salts condemning the light in very strong terms, inquired the nature of their objection to it. The answer was that the reflection of the lights was so great on the river that they were blinded by it, and could not see the lights of vessels moving about the harbor. This, it was said, is especially so on hazy nights. Some said they had barely escaped collisions by not being able to discern the lights on approaching vessels. Other captains claimed that the electrics troubled them in discerning the lighthouses in the mouth of the river.

In Coal Mines.—A dispatch of Oct. 3, from Connellsville, Pa., says: Recent explosions of fire-damp have set mine operators thinking how most effectually to protect themselves and their employés against that grave danger. Many shafts in this region are using safety lamps, but they give a dim light and are not very satisfactory, especially to the miners. These and other considerations have moved the H. C. Frick Coke Company to make some experiments with the electric light, with a view to its use in mines. A two-horse dynamo has been placed in the engine house at the Trotter Works. It is driven by a small engine and supplies electricity for lights in the engine room and the tower at the mouth of the shaft and for four lights at the bottom. There is no doubt of the utility or practicability of the light, but the sole question to be determined is that of its cost. It would not be surprising to see within the next year every coal mine in the Connellsville region illuminated with the noonday light of the electric arc.

MISCELLANEOUS NOTES.

Posthumous Honors.—A memorial window will be put in Westminster Abbey, to the memory of the late Sir William Siemens.

Sewing Machines Run Electrically.—No fewer than eighty girls are employed at sewing machines run by electricity, in the establishment of Cooper & Conard, Philadelphia.

A Remedy for Electrified Belting.—The *Manufacturers' Gazette* has this: "H. H. Veitch, of Quinapoxet, writes as follows: 'When the belts in a mill generate too strong a current of electricity, a little free steam permitted to escape into the room will stop it immediately. Managers of mills are obliged to do this every day in winter, and particularly so about the vernal and autumnal equinox. A belt passing out of one room into another will generate a current of electricity in proportion to the difference between the temperature of the rooms. Thus a belt running out of an extremely cold room into one extremely hot produces an exceedingly strong current of electricity.'"

STOCK QUOTATIONS.

Telegraph, telephone and electric-light quotations at the New York Stock Exchange, Boston Exchange and elsewhere, are as follows:

Telegraph.—Am. Cable, b 53½, a 56½; Postal stock, b 2¼, a 4; Postal sixes, b 25, a 30; Western Union, b 64¼, a 64⅝.

The notable event of the week has been the reduction of the Western Union annual rate of dividend from 7 to 6 per cent. The reduction has been utilized by the bears.

Telephone.—Am. Bell, b 185, a 186; Erie, b 19, a 20; Mexican, b 1¾; New England, b 29½, a 30; Tropical, b 1¼.

The Boston *Herald* of Oct. 5 says: The dealings in telephone shares were again the local feature. It happened in times before the late panic that telephone stocks were active when all else was dull. It may be so again; to-day's transactions point that way, and all comes of the recent legal agitation in the Bell-Drawbaugh case. Friends of the Bell Company are so confident that they will win that they do not seem to think it necessary to await the decision of the court before putting up the stock. Some say it is good for 300. The more conservative fix 200 as a more reasonable price. The stock made further progress toward that figure to-day, rising to 189, where it grew weary and fell back to 185. The advance was on sales of 208 shares; the decline on sales of 19 shares.

Electric Light.—Edison b 50, a 95.

BUSINESS NOTICES.

Metal Specialty Works.—These works, 104 Elm street, make articles for patentees and furnish models, etc., in the most perfect and accurate manner. The necessity of having a good model is often overlooked by inventors, and the bad practical illustration furnished by their rough model to capitalists and others prevents them from obtaining the financial assistance they need. The Works offer not only to execute orders thoroughly, but to be prompt and charge only low prices.

A warning.—Winter is upon us, and with its approach hundreds of operators, book-keepers and clerks find themselves out of work, and with no means of support, many of whom had good positions which they gave up because they were no longer able to cope with the increasing duties, and for what reason they know not, except that they cannot wield the key to form the Morse letters, or have lost their grip upon the pen. This is the first stage of the rapidly increasing malady known as "writers cramps" or "incipient paralysis." The proper remedy taken in time will remove the trouble and perfect a permanent cure. There is no necessity for leaving your work. Rest does not cure this trouble. "Armaline" has cured hundreds, and it is claimed will not fail. Send to Armaline Co., Austin, Ill., for treatise.

OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS.

Edited by N. S. KEITH, Electrical Engineer and Expert, 9 Murray Street, New York.

PATENTS DATED SEPT. 23, 1884.

Automatic Electric Shut-off for Water and Gas Pipes; T. P. Hughes, Denver, Col.... 305,595

Consists in an automatic shut-off for water and gas pipes, constructed with a spring-held lever, a connecting-lever, and a drop-rod interposed between a stop-cock in the pipe and the armature of a magnet having an electric thermometer placed in its battery-circuit, whereby a fall of temperature below a fixed point will break the electric circuit and release the rod, allowing it to close the stop-cock and shut off the water or gas.

Electric Arc Lamp; R. H. Mather, of Windsor, Conn..... 305,617

A clamp for the carbon. A cylindrical holder is pinched by being turned into its socket so as to grasp the carbon.

Electrical Conductor; T. S. Reed, of Bridgeport, Conn. 305,475

A central air chamber is made lengthwise through the cable.

Electric Fire-Alarm and Call-Bell System; P. Gugerty, Waterford, N. Y..... 305,688

Provides means whereby the strength of the current can be changed at will.

Electrical Railway; B. Bidwell, Grand Rapids, Mich..... 305,730

A longitudinal-slotted tubular conductor, with the slot beneath, is traversed by a conducting brush fitting the tube and supported by a bar passing in the slot.

Electric Railway; E. M. Bentley, Brooklyn, N. Y.. 305,729

Consists in devices for permitting electric locomotives to be run in multiple series.

Electric Railway; W. H. Knight, Cleveland, O.... 305,694

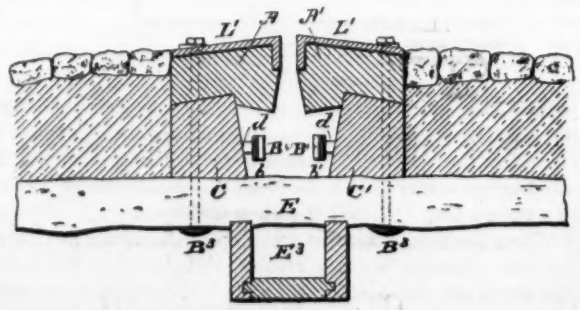
Consists in an arrangement whereby the locomotives on an electric railway may be divided into groups containing constantly the same number of locomotives, the locomotives of each group being in multiple arc and the groups being in series.

Electrical Signaling Apparatus; J. K. D. Mackenzie, Westminster, Eng..... 305,611

Arranges an electro-magnet in the annunciator-circuit, the core of which is magnetized and demagnetized when the contact is made and the circuit is acting properly, and in combination with this a piece or disc of iron, which may form part of the core magnetically, and which emits sounds as the core is magnetized and demagnetized.

Electric Railway; W. H. Knight, of New York City..... 305,731

The figure shows the conduit, which is placed under ground, with its top and slot flush with the surface, and which is made up of the four timbers *A A' C C'*, supported on cross-ties *E* over the supplementary draining-conduit E^3, and held by vertical bolts B^4. It will be seen that this form of conduit gives complete resistance to side-thrust of the earth, and the two top pieces *A A'* can be easily removed for repairing and inspecting the interior of the conduit. The timbers have the top plates of iron *L' L'*, which are bent down into the slot at their inner edges. The



under surface of parts *A A'*, being inclined, will serve as a watershed, so that the drippings will fall clear of the conductors. The joints can be tongued and grooved or made with inclined surfaces, as shown. Within the conduit, on the opposite sides thereof, are two conductors *B B'*, supported on a rail *b*, which is held out from the surface of the conduit by wooden pins *d d*. If the face of the conduit and the pins be well oiled, this arrangement will still further prevent the moisture reaching the bare conductors *B B'*.

Galvanometer; W. G. David, New York..... 305,431

An inclination needle, with a hollow pointer perpendicular to the needle from its axis. The hollow pointer holds a marking fluid, and thereby a registration of deflections is made on a moving strip of paper beneath the needle.

Joint for Electric Conductors; R. W. Kear, Pottsville, Pa..... 305,601

Consists in a joint-piece for electric wires formed of a piece of tubing having a longitudinal slot in one side, and an aperture diametrically opposite the same in the other side, in which aperture a screw is held, which presses the ends of wires passed into the ends of the piece of tubing into the slot in the tubing, thus holding the wires in place.

Secondary Electric Tower-Clock; C. H. Pond and A. S. Munger, Brooklyn, N. Y..... 305,632

Consists in organizing the mechanism as follows: The driving-wheel of a secondary electric clock is provided with a detaining click or dog, which normally engages the teeth of the wheel, thus preventing an accidental movement of the same. The forward movement of the driving-pawl first causes this click to be disengaged from the teeth of the wheel through the agency of a tripping device, thus permitting an advance of the same. The click is then allowed to fall against the next tooth in such a manner as to enter the succeeding space when the wheel has completed its advance movement. The moment the click enters this space it is momentarily locked therein, thus preventing it from being thrown out by a rebound. The return of the pawl to its former position causes the same to engage the succeeding tooth, and the tripping device to be placed in a position to repeat the operation at the next forward movement of the pawl.

Telephone Switch; H. E. Waite, N. Y. City..... 305,552

Consists in the means for connecting the telephone circuit at the subscriber's station so as to normally include the signaling or calling apparatus, and when the telephone instruments at the station are in use to include the latter in the circuit, to the exclusion of the signaling devices.

Telethermometer; W. H. H. Barton, Brockton, Mass..... 305,499

Consists in opening or closing an electric circuit by means of a vibrating needle-arm coming in contact with adjustable slides to which are connected or attached the wires from a galvanic battery. The needle-arm is connected with a standard on a metallic plate, and is vibrated by the contraction or expansion of a bi-metallic circular strip, which is fixed at one end and supported by a standard on the metallic plate, and is movably connected at the other end with the needle-arm.